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METHOD OF MACHINING ARTICLES AND
SOLUTION THEREFOR

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This invention relates to machining of articles, and particularly to an improved method of grinding of metals and a solution or coolant therefor.

For the purposes of illustration, the method and solution are described hereinafter in connection with high speed centerless grinding, the use thereof in connection with other cutting, drilling and machining operations being readily apparent from the illustrative example.

The abrasive wheels used for centerless grinding operations usually are mounted on a hollow enclosed base or support which acts as a temporary storage for the grinding solution or coolant. Usually, one part of the hollow base is partially separated from the remainder by suitable baffles and the like, so as to provide a sump into which the solution in the base drains and to which the inlet side of a pump is connected. The pump is arranged to draw the grinding solution or coolant continuously from the sump and discharge it onto the article being ground for the purposes of cooling the article and abrasive wheels and removing freed particles of metal and grit from the grinding throat during the grinding operation. The grinding solutions commonly used comprise aqueous solutions of soluble oils, though for some types of work, more expensive grinding pastes are used, for example, sodium or potassium oleate, formed by the neutralization of oleic acid, or sulphonated oils with which are mixed sodium hydroxide or potassium hydroxide.

It is known that freshly dressed abrasive wheels grind rapidly, accurately and efficiently, but that after the wheels have been used a short time, the contours of the grinding faces become rough and inaccurate and the grinding efficiency is reduced so that an appreciable number of the articles ground thereby are scratched, scored, and ground unevenly or otherwise damaged so as to be unsuitable for their intended purposes.

When these conditions become aggravated, it is necessary to replace the grinding surfaces of the wheels. Refacing a grinding wheel not only is an expensive and time-consuming operation, but also removes an appreciable portion of the wheel so that the life of the wheel is considerably shortened over what it would be were the sole reduction in diameter due to the normal wear occasioned by grinding operations.

I have determined from a study of commercial grinding that the uneven wear and roughening of the grinding surfaces of abrasive wheels and inefficiency in grinding result not so much from the normal grinding contact with the article, but from the fact that foreign matter, such as abra-

sive and metal particles, dust, grit, powder and chips which are torn loose from the wheels and articles during the grinding operations, remain suspended in the coolant or grinding solution during recirculation of the coolant past the wheels and are transported thereby and discharged continuously onto the wheels and article. Such foreign matter is held against the operating surface of the wheel by the solution and the finer particles and chips are carried into and deposited in the pores, interstices, or cavities between the surface grits of the wheel. As a result, the cavities become plugged and reduce the coarseness of grind, cause uneven projections on the surface which cut and score the work piece or article being ground, and cause uneven wear and a resultant change in the contour of the grinding surface. Likewise, without adhering to the wheel, chips of metal and abrasive are carried between the article and wheel with resultant scoring of the article and grooving of the wheel.

These conditions become so pronounced after a short interval of operation that a wheel of a given grit is not efficient for the rate of grind for which it is made, but, in fact, becomes much less abrasive than intended. Thereafter, in a somewhat longer interval, its surface becomes roughened and irregular in cutting quality due to numerous projections of imbedded foreign matter, and also becomes scored with the coarser abrasive dust, metal dust, and chips temporarily lodged between the article and wheel. However, a cutting and coolant solution must be used to protect both the work piece and the abrasive wheels from excessive heating and to wash all dust and chips away from the grinding throat. Therefore, if these objectionable effects are to be overcome, efficient removal of abrasive and metal dust, chips and like foreign matter from the coolant or grinding solution is necessary.

In the usual commercial grinding machines, the sump and hollow base of the machine are provided with strainers and baffles through and around which the solution must pass, and during this passage the metal and abrasive particles and chips are expected to settle out the solution. Some extremely coarse particles are strained from and settle out from the solution in the sump, but the solutions retain many particles in suspension for such long periods that they are drawn into the pump, recirculated and discharged back onto the wheels and work piece with the solution. The same conditions exist in connection with other machining operations and cause dulling, heating and jamming of the tool.

One of the principal objects of the present invention is to provide an improvement in the present methods of grinding and machining by which these disadvantages and objectionable effects are eliminated.

An equally important object is to provide a solution for the purposes described and which is of such a character that any metal, and abrasive particles, chips, and like foreign matter which are introduced into the solution do not remain suspended in the solution but drop or settle out of the solution almost instantaneously, or at least during the interval of passage of the solution from the work throat or tool and return under normal industrial grinding and like operations, so that the solution at all times is clean and free from suspended foreign matter.

Another object is to render the solution capable of more effective contact with the surface of the article being ground or machined and with the surface of the abrasive wheels or tool so that more efficient cleaning and cooling is provided.

Another object is to provide a solution capable of cleaning the work piece and the abrasive wheels more efficiently so that the wheels can be operated at all times and can cut and grind at their rated capacities.

A correlative object is to provide a solution which is both an efficient detergent and coolant, is harmless to the operator, does not deteriorate and become rancid as do soluble oils, is odorless, of which the dry ingredients readily dissolve in and mix with hot or cold water without being subjected to expensive mixing operations and mixing apparatus.

Other objects and advantages will become apparent from the following specification.

I have found that such chips, grit and other foreign particles and matter are seldom free from the usual industrial oils and greases, shop dirt, and the like. Since the surfaces of the tools and the articles are coated with films of oils, greases and the like, as they drop into the solution, necessarily part of the oils and greases remains and accumulates therein. As a result, the solution itself, at the tool site, carries the oil onto any particles which might otherwise be clean. Thus, even though soluble oil solutions are not used, the particles of the tool and work piece have oily and greasy surfaces when they are discharged from the tool site.

Such particles can be wetted more readily if freed from the oil and grease films, and if wetted efficiently, will tend to settle out of the solution more rapidly.

Furthermore, by depressing the surface tension of the solution, the tendency of foreign matter to settle out is increased.

Therefore, in order to cause the abrasive and metal particles, dust, chips, and other foreign matter, which are introduced into the solution from articles and grinding wheel or other tool, to drop entirely out of the solution almost instantly, and to prevent any such foreign matter from remaining suspended in the solution for a long enough interval to be carried back to the grinding throat thereby, I decrease or depress the surface tension of the water used in the solution, or of the solution as a whole, preferably far below its normal surface tension, and also clean the surfaces of the particles.

The degree to which the surface tension should be decreased in any instance depends to some extent upon the size and specific gravity of the particles of metal and abrasive introduced as a

result of the particular machining operations and upon the cleanliness of their surface, but must be such that the particles can pass through and settle out of the solution as the solution

passes from the wheel or tool to the sump and before the solution reaches the pump inlet under the normal grinding or machining conditions. For cleaning, I provide a detergent agent which also has high emulsifying or saponifying properties and which, therefore, can remove the oils and greases from the particles in the first instance, or render them less effective in resisting wetting of the particles, and can change the characteristics of the oils, fats, and greases so that even if they are reapplied to the article and tool by the solution, they will not adhere thereto as they would in their normal condition.

These desirable effects can be produced by providing a solution comprising essentially water, a detergent agent, preferably having high emulsifying properties, and a commercial wetting agent, though some individual commercial agents are now available which are highly efficient both as such detergents and as depressants of the surface tension of water.

The principal effects of such a solution are increased efficiency of contact with the article and wheel, of cooling and of cleaning, and almost instantaneous precipitation of grit and metal particles and like foreign matter.

With the prior solutions, the surfaces of the articles and wheels are oily or greasy and consequently are engaged by the solution only in large drops or globules. These drops contact with the surface at any given instant only at spaced areas and then not intimately and efficiently. Due to the detergent and wetting agent, or agents, very intimate and immediate contact of the solution with the entire surface of the article being ground and of the wheels results, not only because the surface is clean, but also because of the more rapid spread of a solution having a lowered surface tension. Consequently, the heat transfer surface is increased and heat is absorbed and removed from the article and the surface of the abrasive wheels much more rapidly by the solution. A correlative benefit results from the fact that since the solution is clean at all times and can wet the wheel surface more efficiently, it not only prevents the depositing of chips and foreign matter on the wheel, but washes away any foreign matter tending to adhere to the wheel or the article being ground. As a result of these effects, the life of an abrasive wheel is very materially increased, its accuracy and efficiency is maintained for much longer periods, and a consistently higher accuracy in finish of the article being ground is obtained.

Any oils and greases carried into the solution are emulsified and saponified so that their undesirable effects are overcome. A solution which is particularly effective for nonferrous metals, or for ferrous metals where slight discoloration of the surface by oxidation is unimportant, comprises water and a very small amount of triethanolamine.

Wetting agents from the amine group generally and also those from the alcoholic sulphate group are very efficient. Commercial wetting agents known as "Duponol," "Orvus," "Tergitol," "Santomerse" are very efficient, though expensive. Duponol and Orvus are trade names signifying wetting agents made, respectively, by E. I. Dupont de Nemours, Inc. and Proctor & Gamble. I understand these to be sulphonated

alcohol products made under secret formulae. Tergitol is marketed by Carbide & Carbon Chemicals Corporation. I do not know its composition. Certain properties of Tergitol, however, are given in a publication "Synthetic Organic Chemicals" published by Carbide & Carbon Chemicals Corporation January, 1938 (9th edition), page 64. Santomerse is marketed by the Monsanto Chemical Company under a secret formula. I do not know its composition. Substantially any commercial wetting agent may be used, but those from the groups enumerated are extremely effective, and though relatively expensive in cost per pound, are exceedingly inexpensive, considering the low concentration in which they are employed. For example, wetting agents in concentrations of 1% of the weight of the water used generally are entirely adequate for even the worst conditions. In fact, triethanolamine may be used in amounts from 0.1 of 1% to saturation. Triethanolamine is desirable additionally because it has a very high boiling point, namely 277° C., and is both a wetting agent and a very efficient emulsifying or saponifying agent. Any amount of triethanolamine in excess of that required for sufficiently reducing the surface tension for the particular use is not disadvantageous except from the standpoint of waste of the wetting agent itself. The wetting agents above referred to are efficient because they reduce surface tension and act as emulsifiers or saponifiers of oils, greases and fats.

Here it should be noted that some ordinary water softeners and soaps, such as hereinafter set forth, possibly may decrease the surface tension of water or the solution but only to a slight degree and as incidental to the primary function of softening the water. Their slight incidental reduction of surface tension is insufficient to prevent foreign matter from remaining in suspension in the solution under the usual conditions of industrial grinding, cutting, drilling and the like above described. Wetting agents, on the other hand, have as their primary function and characteristic the ability, even in very low concentrations, of reducing surface tension tremendously and to the degree necessary for preventing all such foreign matter from remaining in solution under normal industrial machining conditions, and to wet chips even in the presence of the usual industrial oils, greases, and fats. Detergents in addition to the detergent wetting agents may be added. Sodium carbonate, sodium hydroxide, tri-sodium phosphate, tetra-sodium pyrophosphate, sodium tetraborate, sodium metasilicate are very satisfactory.

If the material of the article to be ground is a ferrous metal, and the surface must be free from any oxidation or rust, suitable alkali or neutral salts or rust inhibitors can be added to the solution, the wetting agents specifically classified not being deleteriously affected by such additions. Of the salts used, sodium nitrite, tri-sodium phosphate, potassium carbonate or hydroxide, sodium carbonate or hydroxide, sodium nitrate, borax, or any known alkaline salt may be used. The sodium nitrite is preferred for general machining operations other than grinding because extremely low concentrations thereof are efficient for rustproofing, and though expensive per pound, it is relatively cheap, considering the concentration at which it is effective. I have found it highly efficient in amounts as low as 0.2 of 1%, by weight, of the solution of water and wetting agent. Furthermore, it

can be used in concentrations from about .02% up to saturation, the excess over that required being in no way detrimental to the solution. Sodium nitrite is, however, apt to become decomposed under the heat generated by grinding operations on metal (giving off obnoxious fumes), and sodium nitrate is, therefore, preferred for grinding.

In many grinding operations, especially finish or lap grinding operations, not only is efficiency in grinding important, but a high surface finish generally is desirable or necessary. For providing a high surface finish, suitable soaps may be added to the solution above described. Low titre soaps are preferred because they dissolve at lower temperatures than other soaps. The soap content of the solution may be from 0.2 of 1% by weight of the solution up to saturation. The preferred soap is that now available on the market and sold by the Colgate-Palmolive-Peet Company under the trade name "Kwicksolv-Textolive." This particular soap dissolves almost instantly in water at 33° F. It is understood that it is made by a patented process in which ordinary soap is precipitated from a tower in a closed chamber in a manner to aerate and inflate the precipitated particles, causing them to assume a spongy cellular texture.

The introduction of soap, however, results in foaming, which is very detrimental in grinding operations. In order to reduce the foaming, a de-foaming agent is added to the solution. Octyl alcohol is preferred as a de-foaming agent, particularly since it has a very high boiling point of 184.3° C. About 0.1 of 1% by weight up to the saturation of about .14% by weight of the solution is all that is required. Other de-foaming agents, particularly of the alcohol group, may be used, but octyl alcohol has the additional advantage that it is a solvent for natural and synthetic gums and therefore assists materially in cleaning the wheel and the work piece.

A preferred dry mixture, ready for mixing with water, may comprise, by weight:

	Per cent
A wetting and cleaning agent (triethanolamine or alcohol sulphates preferred)-----	1
An alkali or neutral salt rustproofing agent (sodium nitrite preferred for general machining operations, sodium nitrate for grinding)-----	20
Soap (low titre soap preferred)-----	20
De-foaming agent (octyl alcohol preferred)-----	3
A water softener, such as sodium metaphosphate, sodium pyrophosphate, trisodium phosphate, or any other phosphate salt----	54

However, the above dry mix is very efficient within the following limits:

	Per cent
A wetting and cleaning agent (triethanolamine or alcohol sulphates preferred)-----	½ to 3
An alkali or neutral salt rustproofing agent (sodium nitrite preferred for general machining operations, sodium nitrate for grinding)-----	15 to 25
Soap (low titre soap preferred)-----	15 to 25
De-foaming agent (octyl alcohol preferred)-----	1 to 5
A water softener, such as sodium metaphosphate, sodium pyrophosphate, trisodium phosphate, or any other phosphate salt-----	Balance

If additional detergent properties are desired, such detergents as sodium carbonate, or hydroxide, trisodium phosphate, tetrasodium pyrophosphate, sodium tetraborate, and sodium metasilicate may be used.

The water softeners are added so as to make the solution of universal applicability in soft water as well as hard water localities. The particular water softeners recited also assist to some extent in cleaning the article and the wheels. Water softeners generally, and perhaps those used heretofore, may tend to reduce surface tension of the water and solution very slightly. However, the reduction in surface tension is not appreciable, and even though such softeners and salts are used in a proportion so that the solution is saturated therewith, nevertheless the surface tension remains so little reduced that the abrasive and metal dust and metal chips and other foreign matter remain in suspension and float in the solution for an indefinitely long period and a period much longer than can be tolerated in present day grinding and machining practices. Therefore, in referring to wetting agents, the term is to be construed to mean those agents, the principal characteristics of which is to reduce or depress the surface tension of the water to such a degree that the solution does not retain the type of foreign matter referred to in suspension, or float the same, a sufficiently long period so that it is carried back onto the wheel or tool during a normal grinding operation, but, on the contrary, causes all such matter to settle out within a very few seconds and, in fact, almost instantaneously.

The wetting agents recited have an additional advantage in that they act on the wheel and work piece and prevent any of the fats and oils of the soap from adhering thereto and thus increase wetting efficiency indirectly by their emulsifying and saponifying properties. The solution is continuously flowed over the work piece or article while the work piece is in the grinding throat. Due to the reduced surface tension, transportation and stirring by the solution of the chips already settled in the sump are reduced greatly.

Although the method and solution have been described particularly in connection with grinding, it may be used also for drilling, turning, milling, and any and all other machining operations on metals and other materials.

Having thus described my invention, I claim:

1. The method of removing foreign matter from liquid coolants which are used in machining operations on articles wherein a relatively small volume of coolant is continuously recirculated onto the article and tool, said method comprising depressing the surface tension of the liquid coolant and maintaining it depressed during the machining operations to such a degree that particles introduced thereinto from the tool

and article settle out of the coolant in less time than is required for the coolant to pass from the place of introduction of the particles to the tool and article.

2. In machining operations wherein liquid coolants are continuously recirculated over the tool and article being machined, the step of maintaining the coolant clean and of increased efficiency of contact with the article and tool during continuous circulation thereof by the introduction into the coolant of a wetting and detergent agent.

3. In the grinding of metal articles on an abrasive wheel, the step of continuously washing the wheel and article with a solution of water and a wetting agent, and repeatedly recirculating the solution to and past the zone of operation of the wheel on the work.

4. A dry mix for forming an aqueous cooling solution comprising, by weight:

	Per cent
Triethanolamine	0.5 to 3
A salt selected from the group consisting of sodium nitrite and sodium	
nitrate	15 to 25
Low titre soap	15 to 25
Octyl alcohol	1 to 5
the balance being water softener.	

5. A dry mix for forming an aqueous cooling solution comprising, by weight:

	Per cent
Triethanolamine	About 1
A salt selected from the group consisting of sodium nitrite and sodium	
nitrate	About 20
Soap	About 20
Octyl alcohol	About 3
balance a water softening salt.	

6. A dry mix for forming an aqueous cooling solution comprising a wetting and detergent agent, an alkaline rustproofing agent, a low titre soap, and a de-foaming agent.

7. A dry mix for forming an aqueous cooling solution comprising a wetting and emulsifying agent, a rust-proofing agent, a soap, a de-foaming agent, and a water softener.

8. A solution for the purpose described and comprising essentially water with a small amount of commercial wetting and emulsifying agent, and soap, an alkali rust inhibitor, an alcohol de-foaming agent, and a water softener.

9. A coolant for the purposes described adapted to be used with water as the principal solvent, said coolant comprising a rust proofing agent selected from the group consisting of sodium nitrate and sodium nitrite; a surface tension depressant which is as active in this respect as triethanolamine, soap, an alcohol de-foaming agent, and a water softener.

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CERTIFICATE OF CORRECTION.

Patent No. 2,252,385.

August 12, 1941.

GILBERT H. OROZCO.

It is hereby certified that error appears in the printed specification of the above numbered patent requiring correction as follows: Page 1, first column, line 42, for "replace" read --reface--; page 3, second column, line 1, for ".02%" read --0.2%--; page 4, second column, line 34, claim 5, for "sodilum" read --sodium--; and that the said Letters Patent should be read with this correction therein that the same may conform to the record of the case in the Patent Office.

Signed and sealed this 4th day of November, A. D. 1941.

(Seal)

Henry Van Arsdale,
Acting Commissioner of Patents.

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