GEORGIA INSTITUTE OF TECHNOLOGY
OFFICE OF CONTRACT ADMINISTRATION
SPONSORED PROJECT INITIATION

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Date: January 25, 1978

Project Title: Development of Improved Wire Drawing Lubricant

Project No: A-2093

Project Director: W. H. Burrows

Sponsor: Cook & Company

Agreement Period: From 1/9/78 Until 7/8/78

Type Agreement: Standard Industrial Agreement dated 1/9/78

Amount: $5,000(includes $500 for Patent & Data Rights)

Reports Required: Monthly Progress Reports; Final Summary Report

Sponsor Contact Person (s):

Technical Matters

Mr. Martin C. Corbitt
Cook & Company
Lumber City, Ga. 31549

Contractual Matters
(thru OCA)

Defense Priority Rating:

Assigned to: Technology & Development Laboratory (School/Laboratory)

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Project Code (GTRI)
Other

CA-3 (3/76)

GEORGIA INSTITUTE OF TECHNOLOGY
OFFICE OF CONTRACT ADMINISTRATION

SPONSORED PROJECT TERMINATION

no action

Date: July 5, 1978

Project Title: Development of Improved Wire Drawing Lubricant

Project No: A-2093

Project Director: W. H. Burrows

Sponsor: Cook & Company

Effective Termination Date: 6/16/78

Clearance of Accounting Charges: 6/30/78

Grant/Contract Closeout Actions Remaining: None

- _ Final Invoice and Closing Documents
- _ Final Fiscal Report
- _ Final Report of Inventions
- _ Govt. Property Inventory & Related Certificate
- _ Classified Material Certificate
- _ Other ______________

Assigned to: Technology & Development Laboratory (School/Laboratory)

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Other ______________

CA-4 (3/76)

Final Technical Report
Research Project No. A-2093

"Development of Improved Wire Drawing Lubricant."

By

Herb Burrows

May 31, 1978

Cook & Company
P.O. Box 458
Lumber City, GA 31549
Attn: Mr. Billy Pearson

SUBJECT: Final Technical Report, Research Project No. A-2093, entitled, "Development of Improved Wire Drawing Lubricant."

Gentlemen:

The objectives of the proposed research were as follows:

1. To formulate an oil-in-water, self-emulsifying fluid such that its aqueous dispersion shall be capable of providing superior lubrication and die drawing characteristics to brass-plated steel wire.
2. To formulate said fluid such that its aqueous dispersion shall provide maximum cooling effect to both die and wire during the drawing operation.
3. To incorporate into the design of the fluid formulation the best principles of extreme pressure/boundary lubrication for the purpose of providing optimum performance at minimum cost.
4. To provide as an ultimate formulation a product which will be free of materials which would inhibit good rubber-to-brass adhesion but will incorporate materials capable of promoting adhesion at the rubber-brass interface.

The research program by which these objectives were to be realized consisted of the following items.

1. Information Survey. This information survey was to consist of the accumulation of information on lubricant raw materials, reports and publications on government and industrial lubricant research and a general survey of current and recent literature on lubricant development with specific emphasis upon wire drawing compounds.

2. Development of Test Formulations. Utilizing present knowledge and experience, together with information accumulated in the information survey, series of test formulations was to have been designed and prepared in a laboratory. Each of these test formulations was then intended to be evaluated in terms of the various factors involved in their availability, preparation and performance characteristics. Those formulations which demonstrated satisfactory or superior performance in the laboratory would then have been prepared in sufficient quantities for testing in the wire drawing test facility at Cook and Company.

3. Lubrication and Bonding Tests. These tests were to have been performed by Cook and Company in their own plant and laboratory. At the conclusion of each of these tests, the wire together with the accumulated data would be forwarded to Georgia Tech Engineering Experiment Station Laboratory for tests and examinations whereby the results might be interpreted. Through a process of feedback of information from the tests at Cook and Company and the tests in our own laboratories, modifications of the experimental formulations would be made in order to maximize the performance characteristics of the wire drawing lubricants thus developed.

I. Literature Survey.

An extensive survey of the literature on machining fluids in general, wire drawing lubricants in particular has been conducted, with a special emphasis on fluids. Some general items on wire drawing lubrication were turned up during the course of this survey and even some on dry lubricants. From the rather large number of articles which were contacted in our survey, we have selected a total of 27, covering the period 1954 through 1977. These articles are listed in chronological order in the bibliography at the end of this report. At this point, it would be well to make a few observations concerning various items in this survey.

Salz (1), gives a general discussion of the various types of wire drawing lubricants in use in 1954, including dry granulated soaps, soap-fat paste compositions, compounded oils, petroleum greases, soluble oils, graphite compositions, and soft metals. Those which would be of interest in the research project for Cook and Company would be (a) the soap-fat paste compositions which are dispersed in water at ratios of 1% for fine wire to 7% for initial reductions of rod to produce fluids showing both or exhibiting both lubricants and cooling properties, and (b) soluble oils which are stated by Salz to be used occasionally in place of soap-fat composition as drawing lubricants in high-speed continuous wet-drawing machines because of the relative absence of foaming.

The soluble oil discussed by Salz, is a mineral oil emulsion, prepared by adding emulsifiers such as mineral oil, sulphonates and potassium soaps to straight mineral lubricating oil. The soluble oil thus prepared is discharged into water to form a milky dispersion of oil particles in water. The oil particles, being insufficiently fine form that they remain in dispersion, are carried by the fluid into the dies along with the wire, where they serve to produce a thin film of oil for lubrication of the wire as it passes through the dies. The water, or aqueous phase of this dispersion serves primarily as a coolant, but also as a carrier of the lubricant into the work area requiring lubrication. This type of emmulsion is the most common type of wire drawing lubricant fluid used over the past several decades and is still in very common use today.

An excellent updating of the information presented by Salz is contained in the article by R. K. Brandth (11), on updating the techniques of wet wire drawing. This article is a much more extensive overview of the techniques of wire drawing lubrication, with particular reference to the composition of fluids as they are presently being formulated for this purpose. Of particular interest, is Table 1, showing the ingredients that go into a modern wet drawing lubricant and the function of each of these ingredients. One will note in this table that, rather than incorporating a single lubricant in the typical formulation there may be a possibility of two or three lubricants being used in the same fluid. In addition to the lubricants and to the emulsifiers which must be used in order to disperse the lubricants in water, there also are a number of other agents for specific purposes such as reducing foam, deactivating hard-water salts, solublizing incompatible ingredients and preventing metal corrosion. Thus the modern wire drawing fluid, or for that matter any machine processing fluid, must be not a simple mixture of two or three ingredients but a complex mixture, well-balanced for the purposes of the machining operations to produce the desired results most expeditiously and economically.

A more recent article by Greenwall (26), entitled "Wire Drawing Lubricants, A review, A Preview," presents a still more complete updating of the present status of wire drawing lubricants. Again the compositions of modern lubricating fluids are dealt with fairly extensively; but, in addition, more attention is paid to the synthetic fluids, the manner in which they operate, and the results which might be expected from them. It should be borne in mind, however, that the synthetic fluids discussed in this article are in reality solubilized oils, rather than synthetic materials which may be used alone or as the principle ingredients of lubricating fluids such as the Ucon Fluids which will be mentioned later. The solubilized oils are in essence very finely dispersed mineral oil emulsions, in which the particle size of the oil droplets is so fine that it is invisible to the naked eye; indeed, invisible under the ordinary microscope magnification. This dispersion exhibits two effects which demonstrate that it is a phase separate from the water. One of these effects is Brownian movement, which can be observed in the ultra-microscope, wherein light is reflected from the surface of the article, not making the particle visible, but showing its presence. The very fine particle may be seen to undergo an irregular and jagged motion due to bombardment by the molecules of the surrounding water. The other characteristics which is observed in this very fine emulsion is Tyndall effect. This is observed by exposing the solution, in a somewhat darkened room, to a sharp beam of light passing through it; the path of that light shows up as a very distinct cloud due to the dispersion of that light into the surrounding area. In ordinary light the dispersion appears to be a clear, although lightly colored solution, very much like tea. The fineness of the oil dispersion in the solubilized oils is a key to the superior performance that these materials exhibit in machine operations. The very fine particles of oil are drawn into very intimate contact with the working surfaces of the metal and the machine tool, in this instance the wire and the die, furnishing very thin film lubrication for both the tool and the die. Reduction of friction thereby reduces the production of heat, while at the same time the aqueous phase, (the water) serves to adsorb whatever heat is produced. Thus, both die and work-piece are kept at a low temperature throughout the operation. This combination of effects tends to increase die life, increase possible wire speeds (and thereby, production rates), decrease pollution of the fluid and increase the quality of the product.

Quite a different type of material used as metal working fluid, is the series of Ucon Fluids (27), products of Union Carbide, consisting of polyalkylene glycols of a sufficiently low molecular weight that they are soluble in water. A very significant characteristic of these fluids is an inverse temperature-related solubility in water. Thus at low temperature the liquid will be completely soluble, but a elevated temperature the solubility decreases. At a temperature characteristic of the specific fluid in hand, a portion of the fluid will separate from solution in the form of exceedingly fine droplets, reminiscient of the fine oil droplet dispersions of the solubilized oil, and exhibiting the same type of superior performance as the solubilized oil in lubricating the contact area of die and work piece. Thus, the advantages of the solubilized oils are also obtained by the use of water solutions of the Ucon Fluids. There are also further advantages in that no emulsifying agents are required of these aqueous systems; consequently it is possible to formulate them in such a manner as to have low foaming, or no foaming, for those applications where foaming would be disadvantageous. Because the compositions of fluids to be used, or to be developed experimentally in this research project, were stipulated in the contract as being oil-in-water self-emulsifying lfuids, the Ucon Fluids and other synthetic materials were not considered at the outset as being candidate materials. Later, when it was determined that foaming was an intense problem in the machines in use at Cook and Company, the suggestion was made that some consideration be given to the synthetic materials. However, this effort would more properly be conducted by Cook and Company, rather than in the laboratories at Ga. Tech.

The foregoing literature survey, as briefly discussed herein and as presented in detail in the bibliography, covers a wide spectrum of lubricating fluids suitable for use in wire drawing applications. These references, together with additional references cited within these articles, will provide a very thorough background of information for any future research work which the sponsor may care to pursue in the field of wire drawing lubricants.

It is this survey which served as a guide to the selection of materials for recommendations for experimental procedures in the current project in the laboratory work at Georgia Tech and for testing in the plant and laboratory at Cook and Company.

II. Experimental Procedures.

Using the foregoing literature survey as a guide, experimental formulations were devised utilizing a variety of industrial raw materials, and some of these formulations were in process of being assembled early in March. About that time, we received a call from Cook and Company, in which it was stated that their experimental or testing equipment, which was to be used to evaluate materials which we might submit, was at that time committed to testing some other lubricants material which had previously come to their attention. It was anticipated that their testing of these materials would continue on into April and that they would be unable to test any submitted samples from us prior to that time.

It was also about this time that contacts were made with Matami, Inc. of Doraville, Georgia, concerning a product known as "Micron 10-5," a machining lubricant and coolant of the type described above as synthetic lubricant or soluble oil. The contact was made on the basis of information which was available to Georgia Tech personnel concerning the superior machining characteristics of this fluid, and on the basis of recommendations by Georgia Tech personnel that this fluid should be tested in the Cook and Company machines, prior to further research on the part of Georgia Tech. It was hoped that this fluid would provide for the wire drawing operation the same superior performance which it was known to provide for other machine operations, and that Cook and Company would thereby be placed in a position of meeting its needs for a superior fluid, without the expense of further research. Negotiations between Cook and Company and Matami resulted in an quantity of Micron 10-5 being supplied by Matani to Cook and Company for testing purposes.

Initial tests of Micron 10-5 consisted of wetting or soaking samples of wire in the fluid for a period of time then washing the fluid off and conducting adhesion tests. In these tests the wire is embedded in tire rubber, cured and then drawn in the Instron Testing Machine to determine strength of adhesive bond between wire and rubber. These tests proved to be satisfactory, and the fluid was then tested in one of the machines to determine its capabilities as a wire drawing lubricant and coolant. The test stopped very abruptly when it was determined that excessive foaming occurred and that the fluid could not be used for its intended purpose as long as it had this foaming characteristic.

When the foaming characteristic of Micron 10-5 became known to Georgia Tech personnel, the suggestion was made that Georgia Tech pay a visit to Cook and Company for a conference concerning the machine characteristics which contribute to the foaming problem. This trip was projected for the purpose of eliminating, if possible, any machine characterisitics that would promote foaming of a fluid. The foaming problem is common to virtually all emulsions of oil and water and is very difficult to eliminate without the introduction of defoamers. Silicone defoamers are disadvantageous in the use of the wire as a tire cord reinforcement, because of the decreased adhesion between the tire cord and rubber. In short, it was felt that if there were a machine characteristic which was itself promoting foaming of the fluid, then that characteristic would be a problem with almost any fluid that might be developed in the course of this research project in the class of self-emulsifying oils; also, that the only means of circumventing a foaming problem from a chemical standpoint would be by modifications of the formulation which would be deleterious to the service of the wire product in its intended use in tire construction.

Accordingly, on May 5, 1978, Georgia Tech personnel, consisting of Sherman Dudley, Ben James and Herb Burrows, visited the plant of Cook and Company and conferred with personnel on the matter of machine operation. At that time it was learned that the original construction of the machine had been modified in that a fountain type circulation of fluid over the capstans intended for the purpose of cooling the capstans, had been removed and substituted by the introduction of a spray mechanism, which it was felt provided more efficient cooling of the capstans. It was pointed out by Georgia Tech that a spray mechanism was incompatible with the use of fluids of the type which were contemplated for this research program and that, in consideration of the superior cooling qualities of the fluids that were contemplated, the spraying mechanisms should be unnecessary. It was our recommendation that the machines be returned to the original fountain type construction and, if possible, that agitation or turbulence of the fluid in passing over the capstans be reduced as completely as possible. Several means by which this might be accomplished were proposed.

These suggestions were not accepted by Cook and Company, who indicated that the spray devices then in use would not be modified or removed for the purpose of using any fluid other than the one which is presently in use. The present fluid does not produce a foaming problem with the spraying mechanism as it now stands.

In view of these considerations, it was suggested by Georgia Tech, and accepted by Cook and Company, that further research on this project be suspended and that the project be concluded by the preparation of this final report.

III. Conclusions and Recommendations

1. A thorough survey of the literature on wire drawing fluids has resulted in the accumulation of significant materials of value in this field. A study of these articles will enhance the reader's understanding and appreciation of the many problems encountered in providing superior lubrication and cooling to the wire drawing operation.

2. The accumulated literature has provided an adequate background for the formulation of wire drawing lubricants of various types, including self-emulsifying oil-soap formulations and solubilized oil dispersions. The latter exhibit superior performance through a combination of decreased frictional heating and increased cooling effects.

3. Also included in the literature survey was the class of substances known as synthetic lubricants, those whose aqueous solutions exhibit high lubricity, further enhanced by the effect of "inverse temperature related solubility." Formulation studies did not include the synthetic lubricants.

4. The work of the project was terminated when it was learned that the wire drawing machines at Cook and Company had been modified to include spray application of the lubricant to the wire. This type of application is incompatible with fluids of the oil-in-water emulsion type, except for certain compositions which would (a) exhibit inferior performance or (b) be deleterious to adhesion of wire to rubber in tire construction.

5. It is recommended that serious consideration be given to the advantages of modifying the wire drawing machines to enable them to accept lubricants of the superior breed.

Respectfully submitted,

[redacted]

W. H. Burrows
Principal Investigator

WHB/dti

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