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Test Results of Four Wear-Resistant Coatings

TECHNICAL REPORT

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U.S. ARMY WEAPONS COMMAND

SPRINGFIELD ARMORY
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Project Title: Manufacturing Chemistry, Erosion- and Corrosion-Resistant Coatings

PRON: M1-3-23043-01-M1-M6

Preparing Agency: Springfield Armory, Springfield, Mass.

ABSTRACT

An evaluation of four steel-substrate coatings of supposed high wear resistance was made in this work. The evaluation indicated the following order of decreasing wear resistance: (1) chromium plate containing dispersed diamonds, (2) nickel plate containing dispersed diamonds, (3) chromium plate, and (4) tungsten-carbide impregnated steel surfaces.

CONTENTS

SUBJECT

Test results of four wear-resistant coatings were evaluated.

OBJECTIVES

The purpose of this work was (1) to determine the wear resistance of steel surfaces impregnated with tungsten-carbide and (2) to compare the findings with other coatings for which data are available.

SUMMARY OF CONCLUSIONS

Wear resistance may be rated in the following order of decreasing value:

1. Chromium plate containing dispersed diamonds,
2. Nickel plate containing dispersed diamonds,
3. Chromium plate,
4. Tungsten-carbide (W-C) impregnated steel surfaces.

RECOMMENDATIONS

1. As represented by the samples tested, W-C impregnated surfaces, from the point of view of wear resistance, should not be considered further. However, only three sets of specimens were prepared in a crude experimental setup and these may not represent optimum surface treatment.

2. Additional work on chromium plate containing dispersed diamonds should be considered.

1. INTRODUCTION

The availability of certain new and novel dispersion type coatings has created an interest in the wear-resistance properties characterizing them. One of the methods of achieving these composite structures is by slight alteration of conventional plating techniques. Codeposits of alumina, thoria, zirconia, Teflon, silicon carbide, diamond, and zirconium diboride in nickel and/or chromium have been produced here and at other installations. In this publication, the results, obtained for the wear properties of steel impregnated with tungsten-carbide by means of an arc-fusion process, are presented and compared with those obtained for chromium plate and occlusions of diamond dust in nickel or chromium plate. The tungsten-carbide samples were experimental and perhaps not representative of ultimate capabilities.

2. RESULTS

Falex pins of 3135 steel and chuck jaws of 1137 steel impregnated with tungsten carbide by an arc-fusion process were examined for wear resistance in the Falex lubricant tester by using MIL-L-644 preservative oil.

The results of these tests are presented in Tables I through III. In each of the experiments, listed in these tables, the load slipped considerably and a stable condition was difficult to achieve.

3. DISCUSSION

a. The coefficient of friction values reported in Tables I through III were calculated from the following expression:

$$\text{Coefficient of Friction} = \frac{\text{Torque (in.-lb)}}{\text{Load (lb)} \times \text{Radius of pin (in.)} \times \sin\theta}$$

where $\theta \cong 45^\circ$ (sine $\theta = .707$) and is one-half the angle subtended by the chuck jaws. The geometric factor accounts for the fact that the applied load must be modified to get the normal, effective load. The coefficient of friction is "effective" only because one-dimensional contact along the length of the pin is made instead of two-dimensional contact over the cylindrical surface area.

b. The results obtained in this work for W-C impregnated steel surfaces do not compare favorably with those obtained for codeposits of diamond in nickel or chromium.[1,2] In the case of diamond dispersed in nickel, loads as high as 2500 pounds can be sustained for times up to 2500 seconds; also the pin wear is not as severe as in the W-C samples. Standard chromium plate can maintain loads of 1000 pounds for periods up to 1600 seconds. In the case of diamond dust dispersed in chromium plate, loads as high as 4500 pounds have been sustained for periods of 4500 seconds with low torque and coefficient of friction, with little wear, and without failure of any sort.

Tables (3)

TABLE I

WEAR TEST RESULTS

Sample 1. W-C Impregnated pin with unmodified chuck jaws.

Wt. Chucks Initial	Wt. Chucks Final	Wt. Falex Initial	Wt. Falex Final	Falex, O.D. Initial	Falex O.D. Final
18.7813 gr	18.4347 gr	7.4406 gr	7.2579 gr	0.2507 in.	--
loss 0.3466 gr		loss 0.1827 gr			

Load (lb)	Time (sec)	Coeff. of Fr.	Torque (in.-lb)	Temp (°F)
250	0	0.722 → 1.354	16 → 30	110
250	46	1.354 → 3.16 → 0	30 → 70 → 0	130

The chuck jaws were moderately worn and welded; the Falex pin was heavily gouged and welded.

TABLE II

WEAR TEST RESULTS

Sample 2. W-C impregnated pin with unmodified chuck jaws.

Wt. Chucks Initial	Wt. Chucks Final	Wt. Falex Initial	Wt. Falex Final	Falex, O.D. Initial	Falex O.D. Final
18.7522 gr	18.2429 gr	7.4498 gr	7.1649 gr	0.2505 in.	--
loss 0.5093 gr		loss 0.2849 gr			

Load (lb)	Time (sec)	Coeff. of Fr.	Torque (in.-lb)	Temp(^{o}F)
250	0	0.768	17	100
250	50	3.161→0	70→0	120

The chuck jaws were moderately worn and welded; the Falex pin was heavily gouged and welded.

TABLE III

WEAR TEST RESULTS

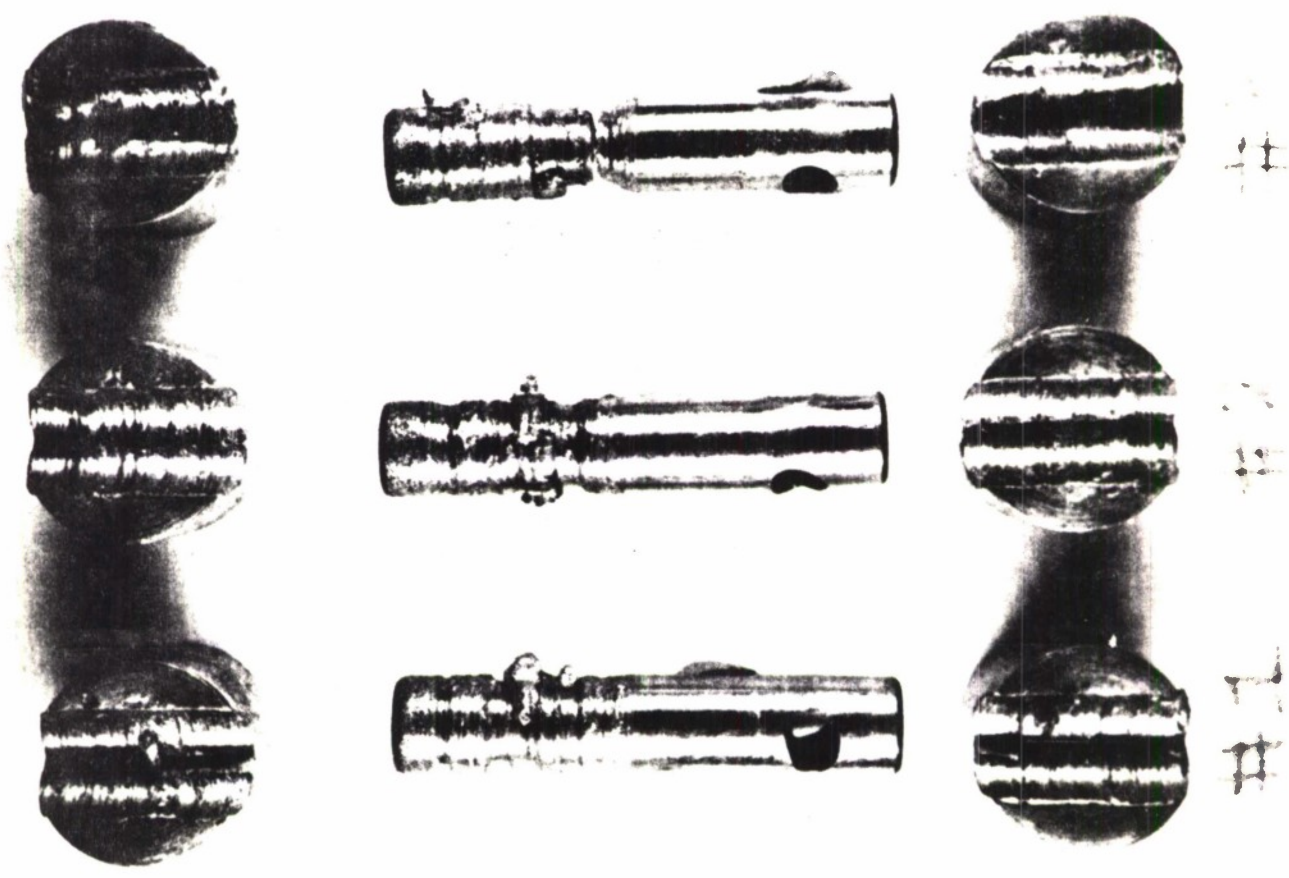
Sample 3. W-C impregnated pin and jaws.

Wt. Chucks Initial	Wt. Chucks Final	Wt. Falex Initial	Wt. Falex Final	Falex, O.D. Initial	Falex, O.D. Final
18.8242 gr	--	7.4261 gr	--	0.2506 in.	--

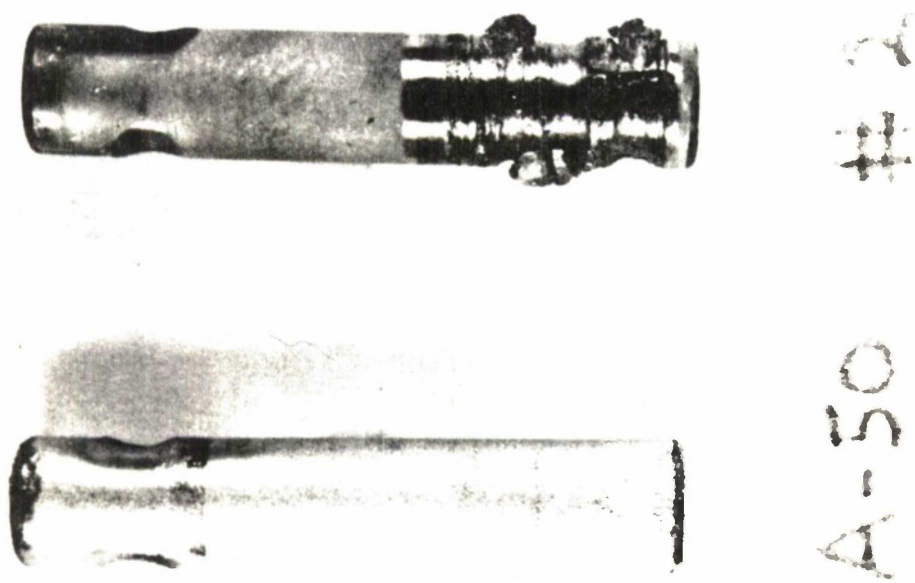
Load (lb)	Time (sec)	Coef. of Fr.	Torque (in.-lb)	Temp(^{o}F)
250	0	0.587	13	90
500	180	0.406→0.903	18→40	115
500	240	0.903→1.58→0	40→70→0	130

The pin, welded to the chuck jaws, appeared heavily gouged.

Photographs



Tungsten Carbide Impregnated Surfaces after Wear Test



#2. Standard Chromium Plate after Wear Test

A-50. Diamond Dust Dispersed at High Current Densities in Chromium Plate after Wear Test

LITERATURE CITED

1. Hassion, Dr. Francis X., "Occlusion of Diamond Dust in Chromium Plating on Steel Substrates," SRB, SA-TR18-1086.

2. Hassion, Dr. Francis X., "Utilization of Occluded Diamonds in Chromium Plate on the SPIW Stripper," SRB, SA-TR18-1087.

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