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MAGNETIC PIGMENTATION IN PAINT

Carl V. Brouillette

Naval Civil Engineering Laboratory
Port Hueneme, California

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MAGNETIC PIGMENTATION IN PAINT

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ZFXX-512-001-030

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ABSTRACT

Several catalytically cured coatings can be applied to wet steel surfaces, but cannot be applied to steel surfaces completely immersed in seawater. The concept of using magnetic particles as part of the pigmentation and applying the paint under water to magnetized steel was investigated. Promising results were obtained from a magnetically pigmented epoxy and coal-tar epoxy. However, methods for inducing a stronger magnetic charge on the steel substrate are necessary. It is recommended that additional coatings, types of magnetic particles and methods to produce stronger magnetic charge on the steel substrate be investigated.

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INTRODUCTION

Attempts to apply paint to steel surfaces under water have met with very limited success. Although specially formulated paint can be successfully applied to steel surfaces wet with seawater or fresh water, many problems arise when attempting to apply this paint under water. Such problems during application include disintegration or dispersion of the paint in water, inability to bond to the wet steel surface under water and failure to completely displace water at the interface between the steel surface and the paint film. Also, hydrophobic and buoyancy relationships between the paint and the seawater prevent suitable adhesion of the freshly applied paint to the steel surface. Thus, it was postulated that the use of magnetic pigmentation in a 100 percent solids paint would give the paint sufficient magnetic properties to be drawn tightly against a magnetized steel surface, even though the steel surface was immersed in seawater. This magnetic attraction could offset the buoyancy effect of the seawater and permit application of the paint to immersed steel surfaces as readily as to steel surfaces wetted with seawater. The induced magnetism would also draw the magnetically pigmented paint into cracks, crevices or pits.

APPROACH

Investigations were made to determine the nature and type of magnetizable pigmentation suitable for producing the desired properties in the paint. Tests were conducted to determine which generic type paints have potential for underwater application. Magnetic pigmentation was incorporated into promising underwater applicable paints and underwater test applications were made on magnetized steel. Observations were made of the specimens under water to determine adhesive, curing and bonding behavior of the magnetically pigmented coatings.

RESULTS

Literature Investigations

A search of the technical literature revealed no instance where magnetic pigmentation had been used to initiate or improve bonding properties of a paint to steel. A reference was found on the use of suspensions of colloidal iron in kerosene and other fluids to produce magnetically induced flow properties.¹ The study of magnetic fluids, or

ferrofluids, is known as Ferrohydrodynamics. The ferrofluids are prepared by dispersing in a fluid colloidal subdomain iron particles on the order of 100 angstroms in dimension. The iron particles usually are coated to prevent sticking to each other, one method being by treatment with oleic acid.

Investigations into sources of colloidal magnetic iron suitable for dispersion into a paint indicated two sources. One was the Ferrofluidic Corporation which sells colloidal dispersions of iron in kerosene, water, silicone and fluorocarbon liquids. These liquids are prepared in various concentrations of colloidal iron which produce saturation magnetizations from 100 Gauss to 600 Gauss. The 600 Gauss ferrofluid in kerosene suitable for addition to a paint costs \$7.50 per cubic centimeter in quantities of 100 to 10,000 cubic centimeters. At this cost the material would be prohibitive for use in preparing magnetically pigmented paint.

It was then decided to investigate the feasibility of using the type of iron particles used in manufacturing audio magnetic tape. Inquiries were made as to the properties and availability of this type of iron. After inquiries were made of Magnaflux Corporation, Ampex Corporation, Audio Magnetics Corporation, and Minnesota Mining and Manufacturing Company, all of Los Angeles, it was decided that two products of Magnaflux Corporation would be investigated. These products were Magnetic Particle, Dry Concentrate 7C Black and 9C Red. These magnetic particles were reported to have an average diameter of 30 to 40 microns, with a few particles being as small as 1/2 micron. The price of either the 7C Black or 9C Red material was \$3.50 per pound. Although the particle size of these materials was not in the colloidal range, they were considered acceptable for incorporating into a paint mixture. The pigmentation in a 100% solids paint, suitable for application and curing underwater, will average over 50% of the weight of the paint. The particle size of the pigments in a paint usually runs between 0.1 and 5.0 micron in diameter.² It was found that 3 to 16% of magnetic iron particles on the total weight of paint was sufficient to give magnetic properties to the paint. This quantity is in the range of 0.3 to 1.5 pounds per gallon.

Laboratory Investigation

The initial laboratory investigations involved preparation of the magnetic iron particles to be used as additional pigmentation. In preparation of the ferrofluids, the colloidal particles were treated with oleic acid to prevent flocculation.³ It was reported that in this preparation the oleic acid produced a 20 Angstrom thick film over the iron particles, which were themselves in the 100 Angstrom range in diameter. The film afforded a cushion or elastic repulsion that opposed forces which could cause flocculation. Treatment of the magnetic iron pigmentation prior to addition to the paint was by grinding the pigment and oleic acid dissolved in mineral spirits in a ball mill for 2 to 4 days. The magnetic iron pigment was then washed with mineral spirits to remove free oleic acid and dried. However, results from the application

under water of paint containing magnetic pigment showed no noticeable difference between the pigment treated with oleic acid and the untreated pigment. Because of the relatively high viscosity and heavy consistency of the high solids paints tested, there was no tendency found for preferential flocculation or settling of the magnetic iron pigmentation after it was mixed into an epoxy or coal-tar epoxy paint.

Table 1, Paint Applicability Tests, gives the coatings, amount of magnetic pigment added and results of application tests. The amount of magnetic pigment added varied from 4 ounces to 1 pound 5 ounces in 1 gallon of paint. The retail price of the magnetic pigment used in these tests was \$3.50 per pound. At this cost the addition of 1 lb/gal would increase the cost of the paint by about \$3.50. Although the optimum quantity of magnetic pigment was not determined, the mix ratio of 1 lb/gal was generally used in the applicability tests. The optimum value would probably vary for different paints.

The initial underwater applicability tests were made on tin plate. It was found, generally, quite easy to apply paint, with or without the magnetic pigment, to tin plate under water. The paint containing the magnetic pigment usually was easier to apply. Induced magnetism in the panel, caused by contact with a magnet, seemed to facilitate application of the magnetically pigmented paint. Also, application of a magnetically pigmented coal-tar epoxy under water to glass, Lucite, and 18-8 stainless steel was found to be quite easy. However, application to sandblasted mild steel under water was not easy.

Figure 1 shows the result of underwater application of a coal-tar epoxy containing 4 gm of magnetic pigment into 50 ml of the paint, to a tin plate panel using a magnet on the back side of the panel for induced magnetism. During underwater curing the coal-tar epoxy flowed across the panel and formed a mound over the top of the magnet which was on the back side of the panel. Thus, the magnetic pigmentation did cause the paint to be drawn to the iron panel and to be influenced by the magnetic attraction.

Figure 2 shows the results of application of epoxy-amine No. 64 under water to a sandblasted steel panel having induced magnetic properties. Panel "a" shows failure of the epoxy, without magnetic pigmentation, to coat the panel. Panel "b" shows the benefit of magnetic pigmentation. This magnetically pigmented coating was easy to apply and bonded well. This coating should be further investigated.

Other coatings, epoxy-amine No. 7103 and epoxy-amine No. 300, could not be applied under water, even with the benefit of the magnetic pigmentation. Some success was obtained with the coal-tar epoxy-amine; however, more experimentation will be necessary if this coating is to be applied satisfactorily under water.

Initial experimentation with the two kinds of magnetic particles used as pigmentation in these tests, 9C Red and 7C Black, indicated the 9C Red to be more promising; however, conclusive tests were not made.

DISCUSSION

The use of magnetic pigmentation in paint for underwater application appears promising. The additional attraction produced by the magnetic particles under the influence of the induced magnetization in the steel substrate assists the paint in bonding to the steel surface. This results in easier application of the paint under water. Experiments with substrates such as Lucite, glass, tin plate and 18-8 stainless steel showed a relatively easy underwater application of a coal-tar epoxy containing magnetic pigmentation, for example. Application of this coating under water to sandblasted steel is unsatisfactory, but under the influence of an induced magnetic field some success was obtained. An epoxy-amine No. 64 containing magnetic pigmentation was quite successfully applied underwater to magnetized steel. It is planned to investigate additional coatings of this type. Also, methods for inducing stronger magnetic fields in the steel are desired. The small permanent magnets used in these experiments were too weak to fully explore the possibilities of the magnetic pigmentation concept.

RECOMMENDATIONS

It is recommended that further investigations be made using formulations based on coating compositions such as epoxy-amines No. 64 and No. 300 and coal-tar epoxy, with additional types of magnetic particles and stronger magnetic fields.

REFERENCES

1. Dr. Ronald E. Rosensweig, "Progress in Ferrohydrodynamics," Industrial Research, October 1970.
2. R. M. Burns and W. W. Bradley, "Protective Coatings for Metals," Reinhold Publishing Corporation, New York.
3. R. E. Rosensweig, "Magnetic Fluids," International Science and Technology, July 1966.

Table 1. Paint Applicability Tests

#	Paint	Mix Ratio (a)	Pigment	%	Treated (b)	Substrate	Applicability		
							No magnetic Pigment	Without Magnet	Magnetic Pigment With Magnet
1	Epoxy-amine #7103	2.2/75	9C Red	3	no	c	fair	fair (c)	better (c)
2	Epoxy-amine #7103	4/150	9C Red	3	yes	c	fair	good	better
3	Epoxy-amine	6/66	9C Red	8	yes	c	fair	good	better
4	TT-E-489c	8/50	9C Red	16	yes	c	good	good	better
5	Epoxy-amine	4/66	9C Red	6	yes	c	good	good	good
6	Epoxy ester	4/66	9C Red	6	yes	d	fair	fair	fair
7	Epoxy-amine #64	4/50	9C-Red	8	yes	d	negative	good	good
8	Epoxy-amine #64	4/50	9C-Red	8	yes	d	negative	good	good
9	Epoxy-amine #64	4/50	9C Red	8	no	d	-	good	good
10	Epoxy-amine #64	4/50	9C Red	8	yes	d	-	fair	fair-good
11	Coal-tar epoxy-amine	4/66	9C Red	6	no	c	good	good	good
12	Epoxy-amine #64	4/50	9C Red	8	no	d	-	good	good
13	Epoxy-amine #7103	4/75	7C Black	5	no	d	-	negative	negative
14	Epoxy-amine #7103	6/75	7C Black	8	no	d	-	negative	negative
15	Epoxy-amine #7103	8/75	7C Black	10	no	d	-	negative	negative
16	Epoxy-amine #7103	2.2/75	9C Red	3	no	d	-	negative	negative
17	Coal-tar epoxy-amine	8/66	9C Red	11	no	d	-	poor	fair
18	Coal-tar epoxy-amine	8/66	9C Red	11	no	Tin-plate	-	good	-
19	Coal-tar epoxy-amine	8/66	9C Red	11	no	Lucite	-	good	-
20	Coal-tar epoxy-amine	8/66	9C Red	11	no	Glass	-	good	-
21	Coal-tar epoxy-amine	8/66	9C Red	11	no	18-8 Stainless	-	good	-
22	Epoxy-amine #7103	4/75	9C Red	5	no	d	-	negative	negative
23	Epoxy-amine #7103	6/75	9C Red	8	no	d	-	negative	negative
24	Epoxy-amine #7103	8/75	9C Red	10	no	d	-	negative	negative
25	Epoxy-amine #300	8/100	9C Red	8	no	d	-	negative	negative

(a) Grams ratio of magnetic pigment to paint
 (b) Pigment coated with oleic acid in ball mill
 (c) Applied in tap water



Figure 1. Amide cured coal-tar epoxy with magnetic pigmentation painted under water onto magnetized tin plate. (Note bump caused by flow of paint to area of greatest magnetic flux.)



Figure 2. Amine cured epoxy primer painted under water onto magnetized steel. (a) Without magnetic pigmentation, (b) With magnetic pigmentation.