PREPARED HEAT RESISTANT PAINT

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Abstract - Now days, faster, stronger, lighter, safer, durable ….with highly cost effective, these demands are constantly being pushed upon by today's researchers and manufactures. High Heat resistant coatings are gaining popularity with the introduction of more sophisticated in Chemical Industries' Equipment Coating like Steam pipe, Heat exchanger, smoke stack, Reactor, furnace, evaporator, pipe, and boiler and also in automotive, aircraft exhaust equipment.
Conventional organic coatings (like epoxy coatings) fail when used at high temperatures.

A coating is a covering that is applied to the surface of an object, usually referred to as the substrate and coatings are applied to improve surface properties of the substrate, such as appearance, adhesion, wettability, corrosion resistance, wear resistance, heat resistant, and scratch resistance. Coating and printing processes involve the application of a thin film of functional material to a substrate, such as paper, fabric, film, foil, or sheet stock. Coatings may be applied as liquids, gases or solids.

Index term: Coating, Pigment, Solvent, Additives, Resin

I. INTRODUCTION

All objects are valuable at their surface. It is the surface of any article that makes continual contact with the corroding (or oxidizing) air. The surfaces of objects left in the open bear the brunt of the sun, rain, fog, dew, ice and snow. Under these conditions iron rusts, wood rots (or shrinks and cracks) and road surfaces crack and disintegrate. These, and more sheltered objects, suffer the wear of daily use, scratches, dents and abrasions- at their surfaces. To prevent or to minimize damage, man applies to these surfaces various coating designed to protect them. Coating can also be used to decorate the articles, to add colour and lustre and to smooth out any roughness or irregularities caused by the manufacturing process. Paint is a loosely used word covering whole variety of materials: enamels, lacquers, varnishes, undercoats, surfaces, primers, sealers, fillers, stoppers and many others. Is essential to grasp at once that these and other less obviously related products, such as plasters, concrete, tars and adhesives.The simplest form paint is whitewash and, when dry, whitewash is nothing more than a pigment-whiting (calcium carbonate)-sprayed over a surface. It decorates and to some extent it protects, but it rubs off. So most paints contain the second ingredient, a resin polymer, film-former or binder, to bind together the pigment particles and hold them on to the surface. Paint is a mixture of filmogen (film forming material, binder) and pigment. The pigments impart colours, and the filmogen, continuity; together, they create opacity. Most paints required volatile thinner to reduce their consistencies to a level suitable application. An important exception is the powder paints made with fusible resin and pigment. Paint is one of the oldest synthetic substances known, with a history stretching back into prehistoric times. It was made more than 35 000 years ago by prehistoric man as they mixed clays and chalks with animal fats and used these paints to depict their hunts on cave walls.

Four Types of Heat resistant coatings generally used

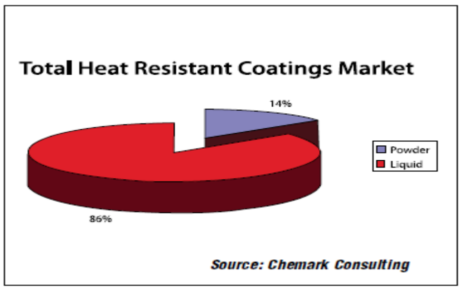
Coatings are found in several related yet distinct applications:

- High-build surface insulation coatings for industrial use and to improve the thermal efficiency of older buildings;
- Heat-reflecting (using IR-reflective pigments, not necessarily high-build) coatings,

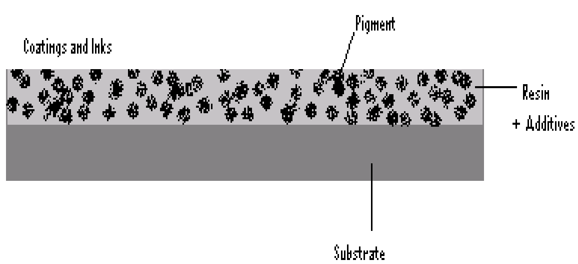
particularly useful for roofing systems in hot climates;

- Coatings resistant to high temperatures during service; and
- Coatings which retard the spread of fire or minimize fire-related damage to structures.

Market Data for Heat Resistant Coating



Constituents of Paint
Resin
Pigment
Solvent
Additives



II. HEAT RESISTANT PAINT

Heat resistant polymers are that paint which can sustain high temperature environment to external and internal application. Heat resistant paint used for chimney stack, pipes, petro-chemical & water tank, boiler fronts, duct work, piping and furnace structure. These paints give good performance in external & internal application. Due to higher reflectance value this paint has special use in coating exterior of storage tanks in oil industry.

Heat resistant paints and surface coatings must offer continuous service at temperatures between 200 and 650 °C with no discoloration or loss of adhesion.

This puts extreme demands on the binder and formulation. These coatings must not degrade under severe thermal stressing and should adhere firmly, whatever the temperature range. SILRES® silicone resins have proved particularly effective even in long-term applications. This is because they have a very high inorganic content and develop their high performance perfectly in different paint and coating system.

Certain organic binders, notably phenolics and epoxies, are tolerant of relatively high temperatures without modification, but coatings designed to provide protection against high service temperatures generally incorporate silicon in some form or another. Since the silicon bond requires much higher energy for its disruption than the corresponding carbon bonds in analogous molecules, it is much more resistant to thermal degradation. Silicone is so effective in this respect that some degree of thermal resistance can be achieved simply by cold blending ten percent or more of a silicone resin with a conventional binder. The temperatures that such a coating will resist are limited to approximately 220°C. Copolymerization, even with modest levels of silicone resins, is more efficient, and can be achieved with, for example, alkyds, phenolics, epoxies, acrylics and saturated polyesters.

III. STRUCTURAL REQUIREMENT OF HEAT RESISTANT PAINT

The main structural requirement to be heat resistant is,

- Presence of high strength in primary bond of polymer backbone.
- Presence of aromatic ring structure.
- Presence of functional group such as sulfone group amide linkage, imides linkage, CF2 group increases heat resistance.
- Halogen containing polymers mainly fluorine containing polymers.
- Presence higher secondary attraction (dipole-dipole attraction), resins of ladder structure (polymers containing series of ring structure linked to each neighboring ring by at least two bonds are known as ladder polymers.) Heat resistance up to 650 °C combined
  - with perfect adhesion
  - Durability under extreme temperature
  - Variations.
  - Long-lasting corrosion protection.
  - UV and weathering resistance.
  - Low-VOC formulations possible.

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RESINS USED IN HEAT RESISTANT PAINT

1. Epoxy Resin

2. Silicone resins

MANUFACTURING PROCESS OF PAINT

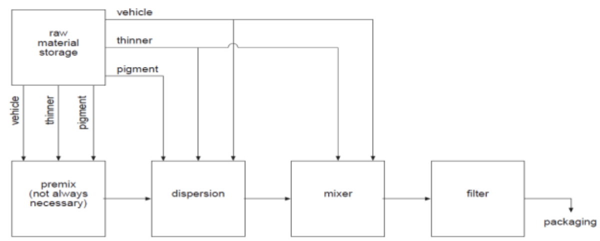

Figure 1: Paint manufacturing process

MATERIAL AND METHODS

Raw Material Selection

Resin
a) Epoxy Resin
b) Silicone Resin
c) Polyamide Resin as Hardener

Pigment
a) Titanium Dioxide
b) Carbon Black
c) Aluminium Paste

Solvent
a) Xylene
b) Methyl Iso-butyl Ketone
c) Butyl Cellosolve

EXPERIMENTAL RESULTS and DISCUSSION

Testing of Paint

1. **Density Measurement**

% of Pigment		50:50	60:40
Tio2	10%	1.01	1.03
	15%	1.03	1.01
CB	10%	0.99	1.05

	15%	1.03	1.00	
Al	10%	1.00	1.01	1.03
	15%	1.04	1.05	1.01

All the Batched samples density ranges from 0.99 to 1.05gm/cc

2. Viscosity

% of Pigment		50:50	60:40	75:25
Tio2	10%	65	61	60
	15%	70	78	73
CB	10%	69	70	64
	15%	65	68	69
Al	10%	60	62	67
	15%	66	68	70

3. Pot life

% of Pigment		50:50	60:40	75:25
Tio2	10%	3hrs	4hr	5hr
	15%	3hrs	4hr	5.30hr
CB	10%	3hr	4.5hr	5hr
	15%	3.5hr	4hr	5hr
Al	10%	3.10hr	4hr	5.10hr
	15%	3hr	4hr	5.30hr

As the epoxy content increases the pot life duration increases compared to 50:50 composition

Drying Time

% of Pigment		50:50	60:40
Tio2	10%	6 hrs	7hr
	15%	6.50hr	6.30hr
CB	10%	6hr	7.20hr
	15%	5.40hr	7hr
Al	10%	6hr	7.40hr
	15%	7.10hr	7.40hr

Curing Time:

% of Pigment		50:50	60:40
Tio2	10%	8hrs	9.40hr
	15%	8.50hr	9.20hr
CB	10%	9.10hr	9.20hr
	15%	9.30hr	10hr
Al	10%	9hr	9.20hr
	15%	9.10hr	8.50hr

Surface to Touch Time

% of Pigment		50:50	60:40
Tio2	10%	40min	2hr
	15%	1hr	1.30hr
CB	10%	1.10hr	1.20hr

	15%	60min	1hr	2hr
Al	10%	1.20hr	1.40hr	1.5hr
	15%	1.10hr	1.40hr	1.30hr

Complete Dry time

% of Pigment		50:50	60:40	75:25
Tio2	10%	4hrs	5hr	5.20hr
	15%	4.50hr	5.30hr	4.30hr
CB	10%	4hr	5.30hr	5.25hr
	15%	4.40hr	4hr	3.30hr
Al	10%	5hr	4.50hr	5hr
	15%	4.10hr	3.40hr	4.30hr

Physical and Mechanical Properties of Painted panels

1.Dry film Thickness

Test	Observation
Dry Film Thickness	Ranges from 80 to 100 micron

2. Adhesion Test

Test	Observation
Adhesion Test	Upto 80 to 100 micron thickness there is no detachment of film from the panel

3. Water Absorption test - ASTM D570

% of Pigment		50:50	60:40	75:25
Tio2	10%	0.05%	0.21%	
	15%	0.02%	0.24%	
CB	10%	0.02%	0.24%	
	15%	0.08%	0.26%	
Al	10%	0.08%	0.13%	
	15%	0.1%	0.26%	

As the silicone % increases the water absorption Percentages decreases

4.Impact Resistant Test

Test	Observation
Impact Resistant Test	No failure observed up to 1 kg load fall from 50cm height

5.Scratch Hardness

Test	Observation
Scratch Hardness	No failure observed up to 1 kg load

Chemical properties of Painted panels

Immersion test

Test	Observation
Immersion Test	No Detachment of film from the panel, No Blistering, No chalking, No discoloration observed.

Solvent Resistant

Test	Observation

Solvent Resistant Test	No Detachment of film from the panel, No Blistering,No chalking,No discoloration observed.

Water Resistant Test

Test	**Observation**
Water Resistant Test	No Detachment of film from the panel, No Blistering,No chalking,No discoloration observed.

Salt Spray Test/Corrosion Resistant Test

Test	**Observation**
Salt Spray test	No rusting,No Detachment of film from the panel, No Blistering,No chalking,No discoloration observed.

Heat Resistant Property of Painted Panels

Heat Resistant Test

The heat resistant test methods give the evaluation of the heat resistant properties of coatings designed to protect steel surface exposed to elevated Temperatures during their service life.

The heat resistant capability of painted samples was assessed in two ways:

In terms of

- The highest temperature sustained by the paint and

Painted Panel kept for 24 hr in oven, the epoxy silicone coated panels are exposed to a muffle furnace maintained at the test temperatures for 24 hours.

A visual inspection of the heated panels was made at the end of the each temperature. The failure of the coating was assessed for chalking, blistering, cracking and colour change. Good adhesion and absence of cracking or chalking indicate heat resistant and high thermal stability.

Sr. No	**Tio2**		**Carbon Black**		**Aluminum Paste**	
	10%	**15%**	**10%**	**15%**	**10%**	**15%**
Batch 1	280°c	260°c	350°c	350°c	480°c	510°c
Batch 2	250°c	260°c	310°c	300°c	380°c	
Batch3	200°c	210°c	250°c	270°c	290°c	300°c

The painted panels were placed in a muffle furnace maintained at different temperature according to ASTM specification D 2485. Thus the painted panels are exposed to a muffle furnace maintained at 478K (205^{0}C) for 8 hour, then increases the temperature to

533K (260^0C) for 16 hour. By then increases the temperatures 55K(55^0C)increments, alternating the time periods indicated , to the final temperature maximum the coating gets visual cracking.

478 K (205^0C) for 8 hours

533 K (260^0C) for 16 hours

588 K (315^0C) for 8 hours

643 K (370^0C) for 16 hours

698 K (425^0C) for 8 hours

753 K (480^0C) for 16 hours

808 K (527^0C) for 8 hours

A visual inspection of the heated panels was made at the end of the each temperature. The failure of the coating was assessed for chalking, blistering, cracking and colour change. Good adhesion and absence of cracking or chalking indicate heat resistant and high thermal stability.

Sr.No	Tio2		Carbon Black		Alluminium Paste	
	10%	15%	10%	15%	10%	15%
Batch 1	260°c for 16 hrs	260°c for 16 hrs	370 °c for 16hrs	315°c for 8 hrs	480°c For 16 hrs	525°c for 8 hrs
Batch 2	260°c for 16 hrs	260°c for 16 hrs	315°c for 8 hrs	315°c for 8 hrs		
Batch3	205°c for 8 hrs	205°c for 8 hrs	260°c for 16 hrs	260°c for 16 hr		

CONCLUSION

A heat resistant paint prepared from the epoxy and silicon resins which can withstand temperature up to 500 °c.The development of this paint reduce the cost. The paint can be apply on external/ internal surfaces of the Heat exchangers, steam pipes, chimneys, pipes ,reactors, boilers, evaporators , inner coatings for autoclaves, furnaces etc….. The Paint can be used for the corrosion protection and decorative purpose.

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