Measures and Test Techniques for Fungus Resistance to Aircraft Materials and Equipment

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Abstract

This paper describes the effect of fungal growth on materials and products, deeply analyzes its impact on the materials failure. Indicate that structure design, the materials selection, surface anti-fungal resistance and laboratory test etc. should be utilized to restrain the materials and products to fungal growth. Lastly the anti-fungal materials, fungus resistant coatings and the optimized techniques in fungus test are listed.

1 Introduction

The various species of fungus are widely growing in tropical and subtropical weather areas in the world. Fungi can affect performance and use of materials and products, and cause malfunctions and lead to some serious accidents, thus it is necessary to study the mechanism of how fungi influence materials and products, and give some recommendations in improvement of structure design, materials selection, surface protection, and laboratory test.

2 Failure Mechanism of Fungus Growth

The erosion of fungus on materials can be classified into direct erosion and indirect erosion according to the erosion mechanism. Direct erosion means the fungus obtain nutrient substance directly from the materials, the material will appear obvious destruction or damage after the invasion of fungus, the major damaged subjects are natural materials, synthetic materials and so on; Indirect erosion means the nutrient substances required by the fungus growth are not directly provided by the materials of products, those nutrient substances come from the dust, grease, sweat and other contaminants that are accumulated or tainted on the surface of the materials or products during manufacture, storage and employing. The following are the detailed analyses of damage mechanism of fungus on materials and products.

2.1 Failure Mechanism of Non-Resistant Materials

Non-resistant materials are primarily of natural materials and synthetic materials. these materials are often composed of hydrocarbons. The materials will be gradually decomposed into carbon-containing molecules and carbon dioxide by hydrolysis of organic acid arose by the fungus, and the carbon-containing molecules be turned into the cellular components of the fungus, so the hydrocarbons can be easily utilized as the carbon source and energy source of the fungus. Under some circumstances, some hydrocarbon molecules can be partially degraded or altered slightly. For example, the destruction mode of fungus on alkane and alkene can be generally divided into two groups: mode one: oxygen incorporates in the terminal carbon atoms and destroys the ending; mode two: oxygen incorporates in the carbon atoms adjacent to the ending and destroys the sub-end. The failure mechanisms of different materials are described Below.

- Plastics

Plastics generally contain fillers and plasticizers.

Fillers can be divided into organic filler (such as wood flour) and inorganic fillers (such as mineral). Most of the organic fillers can provide nutrition and make the materials absorb moisture, thus their fungus resistance are not as good as that of inorganic fillers. Plasticizers mainly provide the plasticity to the plastics; they exist in the intervals among macromolecules. Because most of the plasticizers are semi-antifungal and non-antifungal, so the fungus utilizes them continually. If the plasticizer of material surface is consumed, the inner plasticizer will migrate to the surface, then the plasticity turns bad and the aging becomes more easily, so the organic fillers and plasticizers of the plastics are the major root of fungus corrosion damage.

● Natural rubber and synthetic rubber

Natural rubber and synthetic rubber are macromolecular hydrocarbons. Fungus primarily breaks the carbon chains of the rubber, thus their physical and mechanical properties will deteriorate. Secondly，the additive such as stearic acid, argil and other materials can become the food of fungus. Thiobacillus thiooxidans can turn the sulfur of some rubbers into sulfuric acid thus the rubber is destroyed.

●. Paint film

The destruction of paint film is primarily caused by the organic acidic materials produced by the fungal growth. The long-term effect of organic acidic materials will unfold the fat chain of the paint or oxidize the carbon chains, and the macromolecular structure of the paint film will be turned into low molecular structure after the hydrolysis. If fungus grows seriously, the paint film will be penetrated gradually. After fungus grows on the insulating paint, the insulation characteristic will decrease greatly or discharge will happen.

2.2 Failure Mechanism of Metal

There is not any nutrition required by the fungus growth in the metal materials, fungus can not directly destroy the metal through its compositions, but the breakage of metal materials is frequently caused by the chemical electrochemical effects induced by fungal growth. The following are the electrochemical etching process induced by fungal growth:

A. The corrosive materials excreted during the growth and metabolic process of fungus, such as enzymes and acids. These materials will cause the corrosion of steel, copper, aluminium and other metals.

B. Fungal growth will partially seal the surface, bubble will be formed, this will isolate a certain part of the metal surface, the partial electro-chemical corrosion is established under the bubble, and this kind of corrosion is free from the cathodic protection. Under suitable conditions, the metal surface under the bubble will become lively and turn into a pole of a electrochemical cell, moreover metal surface outside the bubble will turn into another pole of the cell, thus the electro-chemical corrosion comes into being.

C. Fungus grows rapidly under the polarized layer or in the polarized layer, thus the biological group grows larger and larger, its continual outspread will generate pressure to the around, some special type of structure will cause rupture, loose or bubble under this pressure. When fungus grows in the coating, rust inhibitor, grease or other materials, this kind of corrosion will cause the protective coating of metals fall off.

D. The depolarization of fungus will cause corrosion. When the electrical insulation layer or polarized layer is formed in one pole of the electro-chemical corrosion, the electro-chemical corrosion effect is suspended. If fungi grow, they not only can consume the nitrate and sulfur accumulated on the eroded pole (such as iron) but also the hydrogen, oxygen and other gaseous products formed on the pole, hence the suspended corrosion process can continue.

3 Measures to prevent fungus damage

In order to make the product free from fungus damage or suffer little fungus damage, effective measures related to materials selection, surface protection, structural design and laboratory test technique must be adopted.

3.1 Adopt materials and parts with good fungal resistance

The primary effect of fungus on products is the corrosion of materials, so key fungus resistant measure is the selection of materials. We had better choose the materials, devices and parts that are insensitive to fungus and have good fungus resistance. Combined with the former experience, the recommended anti-fungal materials are listed in table 1. Therein，the recommended materials in Tab 1 can be used without fungus test prior to use.

3.2 Surface Protection Technique

Owing to not all the utilized products are good fungus resistant materials, so when the fungus resistant ability of the materials and parts cannot meet the requirements, fungicides and resistant coating should be adopted. Fungicides can be added into the paint, rubber and plastics also can be coated on the surface of the materials or products need to be protected, or make the fungicide into tablet and put into the crust of product need to be protected. Fungicide should have an abroad range of preventing fungus ability, good heat resistance, and chemical stability, and should do no harm or little harm to human body, insoluble or minimally soluble in water, should not have bad effects on the physical properties and appearance of materials and products. The recommended protective coating are listed in Table 2.All of the coatings in Table 2 have passed the artificial fungus growth test and one year's natural environment test, their rating of fungus growth are all 0.

3.3 Structural Design

Reasonable structural design can provide protections against fungal growth. Professional guidance such as IEC Publication 68-2-10, MIL-HDBK-454 has recommended some useful measures:

A. Adopt hermetic structure，and fill up with dry and clean gases；

B. The damp cavity should be avoided on the surface of the products while assembling. For example, there should not be any obvious damp cavity between the unsealed twin plug and socket or between the PCB and end connection at special position.

C. In order to prevent fungal growth on products during manufacture, transportation and storage, the water-resistant and fungus resistant packaging can be adopted, and the environment of the production can be modified.

D. The surface of the products should avoid to be polluted by hand perspiration and other contaminations during assembly and employing.

E. The products should be cleaned periodically so as to remove the nutrient substance (such as dust and sand) that the fungus growth required.

F. Put desiccant in the partially sealed part so as to keep the low humidity of the part, avoid fungi grow.

G. If allowed, can use ultraviolet or ozone to sterilize the surface of products.

4 Fungus test

Fungus test is an effective means to assess the fungus resistant ability of the products and materials and it can provide helpful information for the improvement of anti-fungal design, determination of the fungus resistant ability of the materials and reasonable application of the products. Fungus test can be done in the laboratory and in the natural environment, the combined application of those two kinds of test has great meanings in improving and ensuring the fungus resistance of the products.

Table 1 Preferred anti-fungal materials

No	Name	Category or application area
1	Laminated phenolics with high resin content	Common compression molding materials
2	Laminated phenolics modified with nitrile rubber	Used in the conditions with great temperature changes, compression molding material pieces with many metalworks.
3	Cloth plate bonded with epoxy phenolic aldehyde, silicone organic epoxy, silicone organic and aniline phenolic aldehyde	Laminated products, damp proofing treated after processing
4	Fluororubber, silicone rubber, ethylene-propylene rubber and chloroprene rubber	Rubber item
5	Milling with aniline salicylate or pentachlorophenol which takes up 3% of the weight of the glue	Natural rubber
6	Synthetic adhesives based on synthetic resins and synthetic rubbers	Adhesives, sealing materials
7	Impregnating varnishes based on the modified alkyd paint, modified epoxy fat lacquer and organic silicon	Insulation dipping lacquer
8	Employ baking type lacquer and higher baking specifications, avoid the air dry type lacquer	Insulation coating varnish, silicon steel lacquer, insulation lacquer enamel, other lacquer enamels, varnish
9	Adopt the reinforced materials free products bonded by modified varnish and organic varnish, or the products with glass cloth as the supporting materials	Micanite
10	The linoleum with the ground of non alkali glass cloth and dipping treated by modified alkyd paint, modified asphalt lacquer, modified organic silicon lacquer	Insulating varnish cloth
11	Varnished wire insulated by high strength polyvinyl acetal, epoxy, polyurethane and polyester	Varnished wire
12	Silk insulated wire made from the fiber glass encysted by polyester, modified alcohol acid or organic silicate paint	Electromagnetism wire
13	Nylon casing wire insulated by PVC, installation wire insulated by fluoroplastic etc	Installation outgoing line

Table 2 Recommended coating

Application object	Ground	Plating, coating and covering	Application object	Ground	Coating and covering
Metal surface	Aluminum plate	GT－9104	Surface of antennae and case	Copper H62	B04-9 Acrylic enamel（stucco）
	Aluminum plate	GT－9203		Copper H62	J-chlorosulfonated polyethylene epoxy resin enamel（ medium grey）
	Aluminum	GT－9204		A3	LF2
	Aluminum plate	S01－3		A3	Zn
	Steel 20＃ (cold rolling)	D．Ni18/T.DJB-823(1%)		A3	Fluorine coating
	Aluminum LY12－CZ	D．Ag12/T.DJB-823(1%)		A3	H film
	Copper H62-Y2 (cold rolling)	D．Ag18/T.DJB-823		A3	J52-2chlorosulfonation lacquer enamel
	Steel 8AL	D．Zn8.DC/T.6501		A3	A-automatic dry amino lacquer enamel
Printed panel surface	THAB －67	GT－912 organic silicon		Aluminum LY12－CZ	A04-81 amino matt baking enamel
	FR－4	GT－912 organic silicon		Aluminum LY12－CZ	B13-2 sub-white acrylate fatty group
	THAB －67	S31－1 polyurethane		Copper H62	B04-11 acrylic enamel etc
	FR－4	S31－1 polyurethane		Steel	Powder coating
	THAB －67	GC－900		Aluminum 0.8/L5－Y	Powder coating
	FR－4	GC－900		A3	H-901 epoxy asphalt anti-corrosive paint etc
	Circuit board	GT－9104		Aluminum CF21－Y2	S01-3 polyurethane lacquer Ⅱ
	Circuit board	GT－9203		Aluminum CF21－Y2	DD-900 polyurethane lacquer enamel
	PCB board	GT－9203		A3	B04-56 light gray acrylic baking paint
	Circuit board	GT－9204		A3	DD-900 polyurethane light green lacquer enamel

4.1 Natural environment test

Let materials and products directly expose to the natural environment for a long term, and finally assess microbial corrosion. Owing to the truthfulness of the test environment, so such kind of test can effectively and accurately evaluate the destructive effects generated by the integrated action of biological factor (fungus) and other climatic factors. Through the natural environment test of different kinds of materials and coatings, we can assess the anti-fungal ability of the materials and coatings, determine the fungus resistant rank and screen out the sound fungus resistant materials, so as to provide a base for the selection of materials or the product design. On the other hand, this test can evaluate the real fungus resistant level, thus such kind of test is very necessary.

4.2 Laboratory fungus test

Laboratory fungus test is used to evaluate whether the fungus resistant ability of the product complies with the requirements of the contract. We should analyze and investigate the short-cut method of fungus test, lower the experimental cost and ensure the authenticity of the test result. The following items should be considered in the short-cut method:

A. If materials and coating utilized by the products are non-nutrition materials for the fungus, fungus test cannot be taken into consideration, but if the surface of the products gets contaminated during the manufacture, fungus test should be treated advisedly.

B. If the equipment is designated to employ in gas tightness vessels, fungus test cannot be done.

C. If the materials and manufacturing process of the products go all the way with the product that are produced by the same manufacturing unit and have passed fungus test, fungus test can be exempted.

D. If the function check is unnecessary in fungus test, thus the electric parameter unqualified product can be employed as the specimen.

E. In order to ensure the validity of fungus test, the test generally should not be done after the salt spray test and sand-dust test, so as to avoid the salt residual restrain the fungus growth and the sand and dust provide nutrient substance to the fungus, thus fungus is accelerated.

5 Summaries

In order to improve the fungus resistant ability of the product, first choice should be paid on the materials selection, if the requirement cannot be met, the protective barrier such as coatings should be applied to protect the product. On the other hand, consideration should be paid from structural design, and the necessary maintenance and environmental control measures can be adopted to restrain the fungus growth during the service process. Fungus test is an important method to evaluate the fungus resistant characteristic of materials and products, so relevant fungus test which can provide the relevant information support for the improvement of design of products should be carried out in the development, design specification and use of the products.

References

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