AIRCRAFT SURFACE PROTECTION – PRINCIPALES, APPLICATION, FUTURE TRENDS

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Abstract

This paper gives the engineering fundamentals for aircraft surface protection. An overview about the industrial realisation in the final paint shops for single agile aircrafts in Hamburg will be presented in the 2nd part of the session. In addition to technical requirements on surface protection systems as temperature, erosion, influence from chemical media, also economical aspects and environmental needs given by REACH and ACARE, i.e. reduction of VOC emission, water consumption, waste water production and CO2 emission by 50% and energy consumption by 30% will be considered. The main surface protection principles will be explained. Examples of future research and development work to obtain improved material performance, reduced production cycle time/costs and environmental compliant materials and processes are shown.

1. INTRODUCTION

Understanding of material properties and knowledge of the related industrial processes parameters are enablers for structural design solutions for aircrafts. Beside technical requirements and economical needs also aspects resulting from Environmental, Health and Safety legislation are influencing aeronautic industry.

The aim of this session is to give an overview on surface protection principles for aircraft, to show today's application examples and to give an outlook to future trends and developments. Here the engineering basics will be presented and discussed. The main influencing factors and corresponding requirements (including environment, health and safety) will be discussed and the resulting surface protection principles will be explained. The industrial realisation in the final paint shops in Hamburg is shown in [1], [2].

The paper concludes highlighting some actual research and development topics e.g. functional coatings, modelling and simulation as well as new ideas for external surface protection for aircraft performance improvement and production cycle time/cost reduction that are under investigation in cooperation with Universities and research institutes.

2. REQUIREMENTS ON SURFACE PROTECTION SYSTEM MATERIALS AND PROCESSES

2.1. Main technical requirements

Materials used in aeronautic industries and surface protection materials in special are face to a wide range of various and extreme environmental conditions. On the other hand surface protection materials are the enabler for aircraft life cycle. Some main requirements or better influencing factors on the surface protection system are summarized in figure 1.

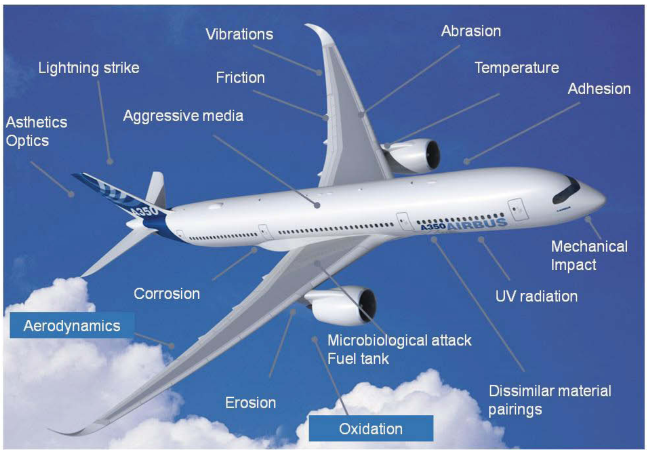

FIGURE1: Main requirements on surface protection system

Surface protection materials need to demonstrate temperature resistance in a range between -55°C up to 80°C. For some special applications temperature resistance up to several hundred degrees is required. It has to protect the structure against various chemical media like water, fuel, de-icing fluid, hydraulic fluids, chlorides, microbiological attack and a lot more. The requirement of surface protection material is to stay several thousands of hours without damage. The s protection system ensures the corrosion protection of metal structures and provides electrical insulation between components made from different materials to avoid galvanic corrosion. Especially CFRP materials need to be protected against UV radiation. The external paint system has to fulfil several special requests from the airliners on aesthetic aspects. Even if this is not a technical requirement, it is of very high importance, because it is directly linked with the customer acceptance of the whole aircraft. Especially at the wing outer surface requirements on surface quality to fulfil aerodynamic requirements are given. In some areas special protection systems are used to provide special properties e.g. wear resistance on the flaps or erosion protection at the leading edges. The main requirement and also the main challenge for the development of new surface protection system is to ensure the long term performance of the system under in-service condition at least for several years (5-6 years) but for a lot of areas for the whole aircraft life.

In addition to these technical requirements also economical requirements need to be considered. In the early 70's Airbus produced a few aircrafts per year in 2011 Airbus builds 40-50 aircrafts per month. It is obvious that a continuous improvement of the materials and processes cost and production cycle time is mandatory to support such production rates and to enable fast ramp up of production rates of next generation aircrafts.

Finally requirements given by environmental legislation as well as Airbus own commitments to implement more and more eco-efficient materials and process have to be respected.

2.2. Environmental requirements

In accordance with the guideline defined by ACARE [3] and EADS Vision 2020, the development of eco-efficient materials and industrial process is necessary to reduce the environmental impact of aeronautic industry. It is mandatory to fulfil legislative requirements for example REACH or solvent legislation and to be inline with EADS internal commitments given in the frame of ISO 14001 certification. In this context environmental friendly materials and processes are enabler for new aircraft design solution and also basis to improve the existing aircraft design and build process.

As consequence of the EADS VISON 2020 it is Airbus target to reduce

- VOC emission by 50%
- Water consumption by 50%
- Waste water production by 50%
- CO2 by 50%
- Energy consumption by 30%

compared to 2006 iso-perimeter and iso-production.

Based on March 2011 figures, 43 entries (groups of substances) are mentioned in the so called REACH candidate list. In figure 2 the distribution of products that contain these substances and are currently in use at the Airbus build process are shown [4]. The highest impact could be easily seen on products used for aircraft surface protection. 89% of the REACH affected products are linked with surface protection. The remaining 11% are spread between metal, composite and assembly technology.

In addition to the technical and economical requirements defined in chapter 2.1 these environmental requirements are a challenge for the development of future surface protection systems and processes.

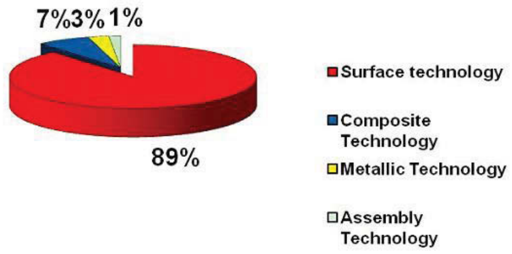

FIGURE 2: Products affected by substances that are part of REACH candidate list (status March 2011). Distribution per technology area [4].

3. SURFACE PROTECTION SYSTEM

Today's aircrafts are designed for an in-service life longer than 20years. Surface protection system in combination with an adapted design solution is key instrument to enable the long live integrity of the aircraft. One of the main challenges is to ensure the long term performance of the surface protection system. Depending from the application on the aircraft surface protection systems need to stay with sufficient performance for the full aircraft life exposed to extreme environmental conditions (chemical media, mechanical loads, extreme temperature and climate cycles...) as shown in chapter 2.

To define the necessary surface protection the aircraft can be classified in three main areas: The internal fuselage, the tank areas and the external area of the fuselage. The focus in the inner fuselage is corrosion and media resistance whereas the external protection system needs also to consider protection against UV radiation as well as aesthetic aspects.

Due to the fact that it is not possible today to combine all necessary functions in only one treatment or coating, the surface protection system is designed as multi layer system. In figure 3 the setup of the structural protection system is illustrated for an aluminium structure. The aluminium alloy is treated by electro galvanic process to generate a layer that provides increased corrosion performance and enables good adhesion for the coating. Today the tartaric sulphuric acid anodizing process is standard [5], [6] and has replaced the chromate acid anodizing process. The basic primer provides an active corrosion protection by corrosion inhibitors.

A similar setup of this basic protection system is given for structures made from carbon fibre reinforced plastics (CFRP). Here the electro-galvanic process is replaced by a cleaning and activation process. On the treated CFRP surface a non inhibited primer will be applied. For areas with increased corrosion protection need (e.g. lower fuselage) the basic protection is followed by an internal topcoat to ensure sufficient resistance against chemical media.

The surface protection system for the assembled structure is completed by the use of seals, sealants and other materials like corrosion inhibiting compounds.

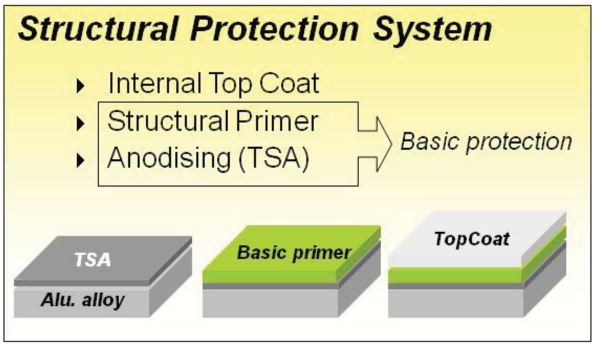

FIGURE 3: Setup of basic protection system for internal and external application.

The main setup of the external paint systems is shown in figure 4. It will be applied on the basic protection system. The external paint primer and the external top coat provide adhesion and resistance against UV radiation and fulfil the aesthetic wished from the airliner. The optional intermediate coat allows and easier paint stripping by the use of chemical paint stripper. Other functionalities as erosion protection or anti-static properties are provided by additional coatings [7]. More details and specialities of the external paint system are presented in [1] and [2].

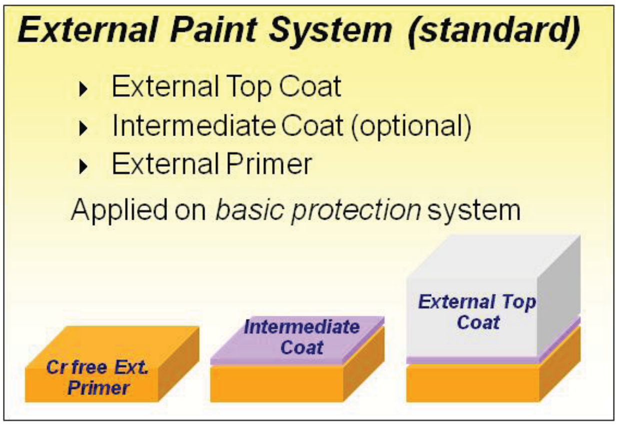

FIGURE 4: Setup of external paint system

4. FUTURE TRENDS

For future research and development in the field of surface protection three strategic objectives need to be respected:

- Improved material performance and functionality
- Reduction of production cycle time and associated costs
- Environmental compliant and eco-efficient materials and processes.

As consequence of these objectives the development of materials (coatings) combining several functionalities are in the focus of actual research work. Surfaces enabling a contamination free or ice free surfaces are intensively investigated. Also materials with improved long term performance for e.g. corrosion, erosion or wear protection are of high interest [7], [8].

To reduce the production cycle time and costs especially during the final assembly of the aircraft various technologies are under investigation that will enable a more efficient use of existing resources and that allow a higher grade of process automation. Technologies for cleaning and activation based on plasma or laser treatment or blasting processes are under investigation [9]. Also new technologies to generate multi-colour surfaces for external livery show promising results. In addition modelling and simulation of material and process behaviour were identified as one key factor for requested development time reduction within aircraft industry. Understanding, modelling and simulation of surface protection relevant effects as e.g. (galvanic) corrosion in mix material assembly (e.g. CFRP-AL…) and its interaction with protection system as well as the environmental conditions will enable significant reduction in definition and development time for surface protection systems and the associated, necessary experimental test effort [8], [10].

The priority in the environmental related research is on the necessary replacement of hazardous substances. Special effort is also given to reach the ARCARE VISION 2020 targets. In addition the development of concepts and procedures for (component) recycling at the end of aircraft life will be continued.

5. LITERATURE

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