Application Note N33e

Simplified Balancing of Composite Flight Control Surfaces after Repainting

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1. Introduction

When repainting aircrafts special care has to be taken with respect to the flight control surfaces, i.e. rudder, elevator, and aileron. For several aircraft types a new balancing of these parts is required. This task can be supported by measuring the paint thickness of these parts before stripping and after the new painting. If the parts are of aluminum or other metal this can be done by traditional non-destructive paint measurement instruments based on ultrasound or eddy current. Such instruments, however, fail if the parts are of carbon fiber reinforced plastic (CFRP or composite). Up to now only the paintborer was available for paint thickness measurements on CFRP. This is a destructive method with a time consuming work.

Since recently, the paint thickness gauge FSC1 from FI Test- und Messtechnik GmbH is available. This instrument uses a microwave based test method and can be used for paint thickness measurements also on CFRP with and without metal mesh. The latter is often used for lightning protection of CFRP parts of aircrafts.

This application note describes the use of the FSC1 in the repainting process of the CFRP flight control surfaces of a Boeing 737-800 owned by TUIfly and the subsequent balancing of these parts.

2. The paint thickness gauge FSC1

The paint thickness gauge FSC1/6 consists of two modules: the measurement module and the display module, see figure 1. The instantaneous measurement area is about 2 cm^2. The measurement time is about 2 seconds. The substrates may be isotropic or anisotropic and may have medium or high electrical conductivity

The readout is independent of the dielectric constant (permittivity) of the isolating layer. In case of layered paint material the complete thickness is measured. In addition to the factory set calibration a calibration by the user is recommended using the CFRP substrate material in use and plastic calibration foils.

Figure 1: Paint thickness gauge FSC1 consisting of the measuring module and the display module.

3. Paint thickness measurements on the Boeing 737 flight control surfaces

The objective of this task is to determine the difference of the paint thickness distributions on the flight control surfaces before the stripping and after the new painting. The calibration of the system was performed using the demounted and stripped trim tab of the left elevator, i.e. on a dark location in fig. 2. Three plastic calibration foils of known thicknesses up to 400 µm were used. The complete calibration procedure lasted about 4 minutes. The calibration values were stored in the instrument.

Figure 2: Brief function test after calibration

Figure 2 also shows a brief function test on a near-by location on the tab with a thin residual paint layer.

Then the paint thickness of the elevator, rudder, and aileron were measured at points which were distributed on top and below these parts with distances of about 20 cm between the points, see fig.3. These points were defined by structural details and by help of a measuring tape. The pure measurement time lasts about 4 seconds per measurement. Three values were taken at each point and averaged. The paint thicknesses varied between 90µm and 135µm. They were displayed directly and also stored in the instrument.

Figure 3: Measuring the paint thickness on the left elevator

After stripping and repainting, these measurements were repeated at the same points using the calibration values which were generated before the first measurement series. The measurement values were stored again. Then for each point the thickness difference between first and second series was calculated and then used for the balancing.

4. Balancing the flight control surfaces

There are two methods to balance flight controls on Boeing 737. Balancing by static balance jig procedure or by calculation. For balancing on jig removal of elevator, aileron and rudder is necessary. For balancing by calculation no removal of Flight Control Surfaces is necessary. Balancing by calculation means measuring and calculation. Difference between the weight of the material removed and the weight of the material added on flight controls gives the new moment calculated per aircraft manufacturer´s Structural Repair Manual. The necessary data for this calculation needs to be as accurate as possible. Results are directly depending on the precision and the handling of the measurement tool used. Using FSC1 on our aircraft reduced man hours and increased measuring precision definitely.

5. Conclusion

Using the paint thickness gauge FSC1 in the repainting process of composite flight control surfaces considerably reduced the effort if their balancing is necessary and when compared with paintborer measurements. This was shown on the repainting of a Boeing 737 and certainly holds for a lot of other aircraft types.

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