ATPI

Deliverable D1

Detailed Specification Document

Abstract: This report presents the detailed specification of the ATPI project at system scale, then at components scale and finally, the foreseen methodologies to characterise the vibro-acoustic performance.

Project is co-funded by Industry and the European Commission within FP6 Aeronauticis

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1 INTRODUCTION

From a feasibility study, ATPI has a global objective to identify an innovating solution to increase the comfort of aircraft passengers by reducing the impact of external noise. Thus, the project is broken down in six operational objectives:

- To adapt the SPADD® Surfacic technology to the aeronautic constraints and requirements
- To use or develop new materials based from cork able to provide the expected damping and thermal performances at low temperature.
- To modify the existing design (or find new shapes) accommodating the new materials while keeping the improved performances;
- To simulate the new damping compound technology, called SPADD®-ATPI for vibration and acoustic characteristics;
- To estimate its performances;
- To prototype and validate by testing, the acquired principles.

2 STATE OF THE ART AND REFERENCE STRUCTURE

In a conventional aircraft, the fuselage is generally assembled from a skeleton of circumferential frames and longitudinal reinforcing members or stringers overlaid by a fuselage skin panel.
To ensure a thermophonic insulation, glass wool mattresses and eventually, damping material are fixed on the internal face of the skin, the overall is then sealed with commercial covering panels.

This vibroacoustic study is focused on the characterization of the external sources impact on the internal noise. The objective of ATPI project is to propose a complementary solution and/or an alternative to the existing acoustic treatments against external sources

2.1 Current solutions

Two types of solutions are usually used to treat the fuselage

- Glass wools:
  Beside its thermal insulation efficiency, the glass wool constitutes an acoustic barrier, mainly for aerodynamic flow turbulence excitations. Its efficiency is significant in broad band frequency noise.

- Tuned Mass systems
  The TMS attenuate the “frame” mode resonance excited by propellers acoustic pressure and correspond to a low frequency treatment.

2.2 Reference structure

From the end Users experience, a cylindrical structure at scale 1/3, stiffened by "U frames"(Figure 1) is identified as representative as an aircraft fuselage behaviour. Such reference structure will be defined and manufactured to characterise the vibration and acoustic performances of SPADD®-ATPI.

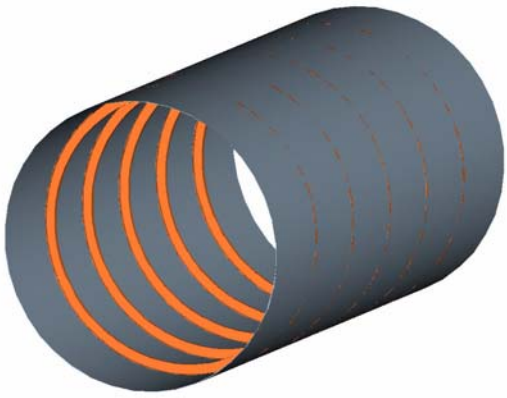

Figure 1 : General view of the reference structure

3 TECHNICAL SPECIFICATION OF NEED

SPADD®-ATPI devices should be integrated taking into account an existing insulation system without major modifications.

3.1 Vibration attenuation performance

Respectively to the 2 types of external excitations, 2 types of performance are expected:

- Attenuation of the vibration level in a broad frequency band.

  Objective, in addition to the current treatment:
  To minimise the increase mass introduced by SPADD®-ATPI treatment to ensure a reduction of 9 dB on the vibration level compared to the reference model.

- Attenuation of vibration corresponding to low frequency peaks.

  Objective, in substitution of the current treatment:
  For a performance at least equivalent to the TMS, SPADD®-ATPI should reduce about 20 to 40% the added mass. The reference structure will be the stiffened cylinder identical without glass wool.

3.2 Acoustic insulation performances

Respectively to the 2 types of external excitations, 2 types of performance are expected:

- Improvement of NR by the boundary layer noise reduction, on a broad frequency band.

  Objective, in addition to the current treatment:
  To minimise the mass of the SPADD®-ATPI treatment to ensure reduction of 5 dB on NR compared to the reference model.

- NR Improvement reducing the noise peaks at low frequency.

  Objective, in addition to the current treatment:
  To obtain an improvement in low frequency noise at least equivalent to the TMS, while saving a added mass of 20 to 40%. The reference structure will be the stiffened cylinder without any glass wool.

3.3 Thermal criteria

The technology will show its efficiency at the operating temperature at - 40°C.

3.4 Material flammability, toxicity and ageing criteria

To ensure any wasted investigation ways, it will be verify that each material used is apart from a list of prohibited materials.

4 SPADD®-ATPI SPECIFICATIONS AT COMPONENT LEVEL.

This paragraph presents the specifications of each element constituting the SPADD®-ATPI device as a adaptation of the generic SPADD®- Surfacic technology.

4.1 SPADD®-SURFACIC properties and SPADD®-ATPI application.

Each component of the SPADD®-Surfacic product is described in terms of material, geometry, function and expected performance.

Taking into account the performance criteria (noise reduction / mass added), it is foreseeable that the SPADD®-ATPI will not cover all exposed area. The proportion of the surface covered by the SPADD®-ATPI device will correspond to the optimum of (performance/mass added).

4.2 Specification at component scale.

ATPI Consortium confidential data.

5 NUMERICAL PERFORMANCE EVALUATION

This paragraph presents the baseline numerical methods for the optimisation process leading to SPADD®-ATPI sizing.

5.1 Vibration performance

From a modal approach (numerical Finite Element Method) and the generic SPADD® Surfacic design rules, the objective is to identify the best compromise between the damping performance, attenuation of the acceleration level (average level) and the added mass.

This optimisation process will be performed:

- with the current materials properties at ambient temperature,
- with the materials properties identified at low temperature, depending on thermal insulation/damping properties brought by each component.

5.2 Estimation of the acoustic impact

The objective is to use an analytical method able to estimate the vibro-acoustic performances of the SPADD®-ATPI on the cylindrical model. This method is based on the excitation of the cylindrical model equipped or not with system SPADD®-ATPI, by an acoustic wave representative of a diffuse field excitation.
The optimised function will indicate the Noise Reduction (relationship between the external pressure and the interior pressure).

6 CHARACTERISATION PROGRAM

During the performance characterisation campaign, three series of measurements will be carried out to identify/validate for the vibro-acoustic performances of the SPADD® ATPI devices.

6.1 Acoustic transmission

The acoustic pressure level will be measured at various points in the interior and exterior of the model.

6.2 Measurements of acceleration level

A set of measurements of acceleration on the model is carried out using an excitation of the same sound field.

6.3 Modal characterisation

A test with impact hammer and/or with shaker will be carried out in order to visualise the frequency singularities of the structure transfer function.