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Vibro-acoustic analysis of micro-perforated sandwich structure used in space craft industry

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ABSTRACT

In satellite telecommunications lightweight parabolic reflectors are made with multi-layered composite material. During launcher lift-off and the first stage of the flight, vibro-acoustic excitations due to the thrust system and aerodynamic forces are the most critical. The random acoustic load applied to the antenna structure becomes very important and can damage the structure and its equipments. To reduce the acoustic loads, micro-perforated thin shell structures are used in order to reduce the acoustic load applied. CAD and numerical software tools are needed to design and optimise such structures. The computation of the acoustic load induced by a diffuse field on a micro-perforated structure is not classical. The aim of this study is to develop a numerical local impedance model to represent the effect of the perforation to be used within vibro-acoustic software.

1. Introduction

In space craft industry, structures are usually made with thin and lightweight composite materials. In particular for telecommunication satellite the parabolic antenna reflectors are made with sandwich composite material based on a honeycomb core covered with multilayered thin and micro-perforated shell structure obtained by weaving like in textile.

This manufacturing process permits an important reduction of the mass and also an important reduction of the acoustic load applied to the structure. However during the liftoff and the first stage of the atmospheric flight of the launcher vehicle, the vibro-acoustic excitations due to the propulsion system and to the aerodynamic forces are the most critical and can be over 140 dB. The random acoustic excitation induced on the antenna commonly known under "blocked pressure" becomes very high and can cause damage to the structure and to the equipments. To avoid these damages, micro-perforated structures can be used, which permit the structure to breathe and then reduce the pressure loading applied to the structure.

The use of this technology for the lightweight antenna is limited to the Ku emission frequency band [12–14 GHz] due to the perforation size between 1 and 2 mm. To cover a higher frequency of emission within the Ka band [20–30 GHz], it is necessary to reduce the size of the perforations to get a correct electromagnetic efficiency of the antenna. Unfortunately, the reduction of the perforation size will increase automatically the pressure jump "the blocked pressure" applied on the structure.

For these reasons, it is very important to have a numerical model describing the impedance of micro-perforated sandwich behaviour to be used as boundary condition in a CAE/CAD software tool for vibro-acoustic prediction.

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