Method for evaluation of bond between acoustic attenuation foam and composite panels of payload fairings of large Launch vehicle

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Abstract

The inside part of the composite payload fairings of space launch vehicles are bonded with special very soft acoustic protection panels. These systems protect satellite inside from very high sound levels at the time of lift-off and also during lower atmospheric regime of flight trajectory. The bonding process is very simple as light press. Adhesive is coated on one surface of the foam. As this foam is very flexible, possibility of folds/debonds cannot be discerned through visual inspection. An acoustic/ultrasonic based NDT method has been developed by the authors. This paper gives a detailed account of the work done and results achieved.

1.0 Introduction:

The acoustical property & speed of sound through foam is of interest when studying feasibility of bond integrity evaluation between foam and composite structure. The speed of sound in foam is determined by the properties of the chemicals creating the foam and the process. Bonding material used on foam to adhere on composite panel is synthetic adhesive. The use of adhesives offers many advantages including the ability to distribute stress more efficiently across the joint.

Authors have developed Acoustic / Ultrasonic based Testing techniques for many non-metallic components and other sound attenuating materials, and implemented for qualification of many space launch vehicle components including composite materials in recent times. The technique discussed here is a state-of-art tool to find de-bonds at the bond line between sound attenuating foam layer and composite payload fairing of space launch vehicle.

2.0 Basic Principle of Acoustic & Ultrasonic based method

2.1 Through Transmission

The foam material is meant for sound attenuation and the authors are using sound for evaluating the bond using through transmission mode. Special transducers of large in size and low frequency (30 KHz & below) for better focusing.
2.2 Pulse echo

The pulse echo method is by means of pitch – catch from same side of acoustic foam from inside of big structure.

3.0 Studies standardization carried out in specimen level:

A standardization plan of NDT for acoustic foam & foam bonded specimen panel interfaces has been worked out. Accordingly bonded specimens of foam-composite panel/ hardware with introduced de-bonds, were fabricated for the purpose of studies. The techniques have been applied on the specimens repeatedly with different operators and found satisfactory and the repeatability of the results is also established by comparison beyond doubt.
4.0 Demonstration of technique in flight article/ Payload fairing:

Sub-Scale level ground test panels are tested with through transmission technique and single side reflection method from foam side. Both the techniques were answering on the de-bond location, results were comparable.

Payload Fairing, while doing ultrasonic scanning manually on a huge structure for de-bond detection, getting co-ordination among transmitter and receiver probes is very difficult in through transmission technique. So, usage of inner surface of foam block (other side bonded on composite panel) for probing both transmitter and receiver eases the scanning.

5.0 Results & discussions

Now, the question arises, if a de-bond between acoustic foam and payload fairing is detected during the above scanning, what next? Authors adopted, first step towards de-bond repair, by soft press again over the location and confirm the integrity once again, if not the de-bond closed, replace the foam block with a new one.

6.0 Conclusion

NDT evaluation of critical interfaces has been made possible by Acousto ultrasonic testing. Methodology was developed, standardized and successfully implemented on actual flight payload fairing at multiple stages. The method is cost-effective and insitu evaluation is also possible. The method has been proved to be satisfactorily detects de-bond between acoustic foam and payload fairing. This method is used in flight articles before and after acoustic test of payload fairing. The article qualified in acoustic test are evaluated ultrasonically and recommended for flight and flown successfully.