Vibration as a Tool for Testing Healthiness of Defence Components

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Abstract

Vibration analysis as a diagnostic tool, for monitoring the health of machinery, structures and equipment is a well proven technique and acknowledged by almost all the industries. Realizing the inherent benefit of implementing the results of vibration analysis, industry is investing in vibration diagnostic equipments. Testing components for vibration is another area where substantial amount of money and efforts are being invested. These are largely required for qualifying defence components. This developmental work of high vibration techniques for testing two important components manufactured for advanced missiles, was undertaken for DRDO.

Key words: Vibration, Testing, Tool, Health, Machinery, Components.

Introduction

The Defence Research and Development Organization entered into a joint venture with Military Industrial Consortium of Russia, to form Brahmos Aerospace, with the aim to develop the supersonic cruise missile BrahMos. The ship and ground-launched versions have a range of 300 km, while the air-launched version has a range of 500 km. The ship and ground-launched version is 8.2 m in length, has a body diameter of 0.67 m, carries a 300 kg payload, and has a launch weight of 3000 kg; the air-launched version is 8.0 m in length, has a diameter of 0.67 m, carries a 200 kg payload, and has a launch weight of 2200 kg. Both versions have four clipped tip delta wings at mid-body, with four small delta control fins at the rear. The BrahMos carries either a 200 or 300 kg high explosive semi-armor-piercing warhead or a 250 kg submunitions warhead [1].
panels coated with BOKMY. This paper gives highlights of milestones reached in perfecting the testing techniques.

**Acoustic Topography Test for Quality of Brazed joints in the Wing Panels**

Fig. 1 shows one view of the Brahmos missile. The four delta wings at mid-body and four small delta control fins on the rear can be seen. These are important parts of the guiding system to make the missile air worthy.

There are two types of wings and one type of fin. All are made of special titanium material. The two wings are named CB-130 and CB-180. Fig. 2 shows CB-130 wing panel.

The panel has a special design. It is approximately 680 mm long, 180 mm wide and 22 mm thick. The dotted lines are boundaries of internal brazed joint not visible from above. Within the boundary, the area is hollow. The acoustic topography test was required to be carried out, to check the quality of the brazed joint.

- The test involved spreading white powder on the surface and exciting the panel by a vibration shaker, so that the powder is displaced along the boundaries. The topography of formation of the powder gives visual impression of the brazed boundary. With this information, the team started working on finer details like
  - Holding arrangement
  - Frequency range of excitation
  - Shaker parameters
  - Selection of powder
  - Density of spread of powder on the panel.

The biggest challenge was fixing the frequency range of excitation and connecting the shaker with the panel. More than 15 varieties of powders were tried. Fig. 3 shows the picture of initial trials when the results were far from acceptable.

For better results, piezoelectric shaker was directly clamped on the panel and excited between 45 to 100 KHz. The holding arrangement of the panel and clamping of the shaker to the panel is shown in Fig. 4.
Fig. 5 shows topography of the brazed boundary after the excitation. The deposit of powder on the boundaries clearly indicates formation of good brazed joint boundaries underneath.

After successful results of the test and approval of experts from Russia and DRDO, more than 150 panels and wings of production units were tested and certified in BARC. In view of increasing volume of work, the technology was transferred to Godrej on MoU with commercial and technical terms and conditions [2].

**BOKMY testing**

The F3 section of the missile is one of the important subsystems manufactured by Godrej. This section consists of an aluminum capsule, which acts as air intake for the engine. The high air intake results in high heat load on the capsule. In order to protect the capsule from the heat load, it is covered with BOKMY coating. BOKMY is a rubber like material on the base of organo-silicon Indian rubber, glass micro spheres and fibrous additions. It is stuck on the aluminum capsule with a special sealant VIKSINT Y-10-28, applied uniformly on the outer surface of the capsule. As per the acceptance criteria, the quality of adhesion of BOKMY to the capsule needs to be checked by a non-destructive method. Good adhesion is a prerequisite for functional success of the subsection.

As the test was to be carried out from the rubber side, no well established NDT technique could be used. The team successfully tried vibration-based technique, to detect patches of poor bonding of BOKMY Several test parameters were tried such as

- Rigid connection of piezoelectric shaker to the capsule
- Frequency range of excitation
- Selection of vibration sensor for measuring is response
- Spectrum Analysis.

Selecting the correct frequency range of excitation and distinguishing the discriminating feature in the frequency spectrum of the response of BOKMY, were the two important parameters for the success of testing. The test involved exciting the capsule in the range of 15 to 20 KHz and measuring the response of BOKMY with accelerometer. BOKMY responds to vibration depending on its bonding with the capsule. Fig. 6 shows comparison of frequency spectrum of BOKMY with good and bad bonding with the capsule.

![Fig. 5: Acoustic Topography of CB-130](image)

![Fig. 6: Frequency Spectrum of BOKMY](image)
It can be seen from the figure that BOKMY responds with higher amplitude around 20 KHz when the bond is good. The repeatability and accuracy of the technique was demonstrated to experts from Russia and DRDO. On request from DRDO and Godrej, BOKMY testing technology was also transferred to Godrej. Fig. 7 shows photograph of testing.

**Conclusion**

Two technologies were developed, implemented and inducted for testing the hardware developed for the DRDO project. Both are unique in characteristics and have nothing in common with machinery diagnostics. One was for testing the quality of brazed joints that are not visible on the surface of the hardware and the other was to check good bonding between two dissimilar materials. Both the technologies were based on rigorous vibration analysis of high frequency signals captured during testing. The repeatability and ease of operation are the highlights of the technologies.

Godrej invested in acquiring the hardware required for conducting both the tests. The team commissioned the test set up at Godrej and handed over to them. The commercial terms have been honored by Godrej.

This is a success story of developing innovative technology by BARC, on demand by the end user, for an important defence project of the country.

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**References**

2. Technical Guidance for setting up test facility at Godrej for carrying out Acoustic Topography test on stabilising wings and panels and for testing quality of Bokmy coating on F3 section. MoU signed between BARC and Godrej May 2009.