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NDE in Space Technology; Premise and Promise

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Extended Abstract

India's space programme started in a modest way by launching a small pencil sized rocket from Thumba, Thiruvananthapuram in November 1963. Subsequently, Indian Space Research Organisation (ISRO) was established for achieving self-reliance in the field of space technology. Today ISRO is in a position to conceive, design, build its own satellites (weighing upto 3-tonnes) and launch vehicles for the purpose of remote sensing and communication. Besides, ISRO is in the advanced stage of building a new generation launch vehicle viz 'GSLV Mk-III' to put 4-tonne plus class satellites in the orbit.

In order to achieve these objectives, the thousands of components that go into the launch vehicles as well as satellites must not only perform satisfactorily but precisely to the specification. Therefore in addition to proper design and manufacture, the successful performance can be ensured only by stringent quality control programmes. Non-Destructive Testing (NDT) plays a very significant role in

this respect. NDT is also applied during various stages of manufacture of huge launch vehicles and satellites since the cost of rejection is prohibitively high. The importance of NDT is further compounded by the fact that every launching is a 'one-shot' affair unlike in the other industries where there is a chance for corrective action if found during performance.

In the initial days, only visual and dimensional checks besides conventional NDT and low energy radiography were used to qualify the components and materials. During late 70's when ISRO was embarking upon launch vehicle programme, high energy radiography facility using 8 MeV Linear Accelerator was introduced for the first time in the country to inspect 1 m dia rocket motors.

When ISRO started building Polar Satellite Launch Vehicle (PSLV) for remote sensing missions, bigger sized solid boosters of 2.8 m dia were required. The inspection and evaluation of these bigger boosters posed lot of challenges and hence the NDT facility was augmented by 15 Mev Linear Accelerator for the radiographic inspection. Pyro technique devices (fast acting high explosive) are also used in space programme to carry out operations like stage separation, ignition, destruction, satellite deployment etc. Inspection and evaluation of these components have to be done only by Neutron radiography. SDSC SHAR has devised an innovative method for generating neutrons by using the 15 Mev Linac with a neutron generator. It is a unique method in which the Linac can be used for X-radiography as well as for neutron radiography. Another significant feature of the PSLV programme is the development of appropriate UT technique for inspection of maraging steel case for the first stage rocket motor. The design is based on fracture

mechanics criteria and requires detection of very tight crack of 3x1mm. A suitable UT technique has been evolved with the help of various institutions in the country for the above purpose. Acoustic emissions (AE) techniques was also introduced during this stage to detect any growing crack which escaped in the initial inspection of motor case.

Due to their high strength-to-weight ratio, composite materials are used in the construction of any launch vehicle and satellite components. Besides conventional X-radiography, pulse-echo, through-transmission, IR and dry coupling UT techniques are employed for NDT of these components. UT is also used for determining the elastic constants of composite materials. In tune with ISRO's future programme of multiple launchings in a year, to improve NDE through-puts, digital radiography is implemented for small components in large numbers.

In the near future, ISRO is poised for enhanced capabilities of launching heavier satellites into geo-synchronous orbit. GSLV Mk-III is a new generation launch vehicle with bigger sized solid boosters of 3.2 m dia for the above purpose. To meet inspection requirements of these boosters, fully automated inspection system is being designed and installed along with film manipulation systems.

Due to special nature of certain components, some challenges are encountered in establishing proper NDE techniques for their inspection and qualification. Some of them are bond interface inspection in multi layered structures and bond-checking of two highly attenuating materials. Improvised NDT techniques are being developed to meet these challenging tasks. Like wise there are number of

potential NDT techniques in the advanced stage of research. One of them is the determination of bond strength by measuring vibrational response by damping characteristics in honeycomb panels. The other one being ultrasonic feature mapping using information from different data acquired from feature domains. Comption back scattering imaging is also being developed for evaluation of materials having small changes in composition.

In space programme, there exists a need for continual optimization of materials, structures and systems. This is because the future launch vehicles, satellites and other spacecrafts are tending to be miniaturized to extract maximum benefits. Thus, more and more never materials are being tried and the existing ones improvised to match the need. Accordingly, there is a need to develop new NDE techniques/extend improvised conventional methods in order to sustain the quality of components and products in space programme.