TARDEC Researchers Develop Sensor-Enhanced Armor (SEA)

Dr. Thomas J. Meitzler

In February 2007, the U.S. Army Tank Automotive Research, Development, and Engineering Center (TARDEC) Armor Non-Destructive Testing and Evaluation (NDT/NDE) Laboratory began exploratory NDT/NDE of ground vehicle armor plates. One of the NDT/NDE team's goals was to determine to what extent sensors could be used to indicate whether armor plates are able to withstand impacts in the field and continue to protect crews and their vehicles.

Ivan Wong (right) and Tom Reynolds use an electric impact hammer to test vibration location results. A computer triangulates the location of each hit using three embedded sensors in the armor plate. (U.S. Army TARDEC photo by Bill Dowell.)

The Armor NDT/NDE Laboratory, the U.S. Army Research Laboratory (ARL), Argonne National Laboratory, BAE, and General Dynamics Land Systems are working collaboratively to understand and improve ultrasonic imaging technology that is being used to diagnose armor health at various stages in the armor life cycle.

The embedded armor crack detection technology uses ultrasonic data obtained by TARDEC researchers to indicate damage to the armor plates. Researchers monitor the signal from damaged and undamaged plates using ultrasonic sensors. Researchers find the armor plates' natural resonant frequency — or sound — and then compare the undamaged to damaged plates.

TARDEC's Intelligent Ground Systems Team is working with the NDT/NDE Team to create a graphical user interface that allows vehicle commanders to know the status of armor plates as indicated by the embedded sensors.

The NDT/NDE Team works with TARDEC's Manufacturing Business Group, which creates the different armor coupon recipes specified by ARL. After the NDT/NDE Team determines a baseline vibration spectrum for undamaged plates, it damages the plates by shooting bullets at them and then takes another ultrasonic reading.

The plates undergo a second embedded ultrasonic evaluation, which obtains high-resolution pictures of the coupons, to determine the extent of the damage. High-resolution pictures are then taken with the in-house X-ray and ultrasound and compared to vibration data. These pictures are compared to data provided by readings from sensors embedded in armor.

SEA uses ultrasonic data measurement in addition to a charted computer display.

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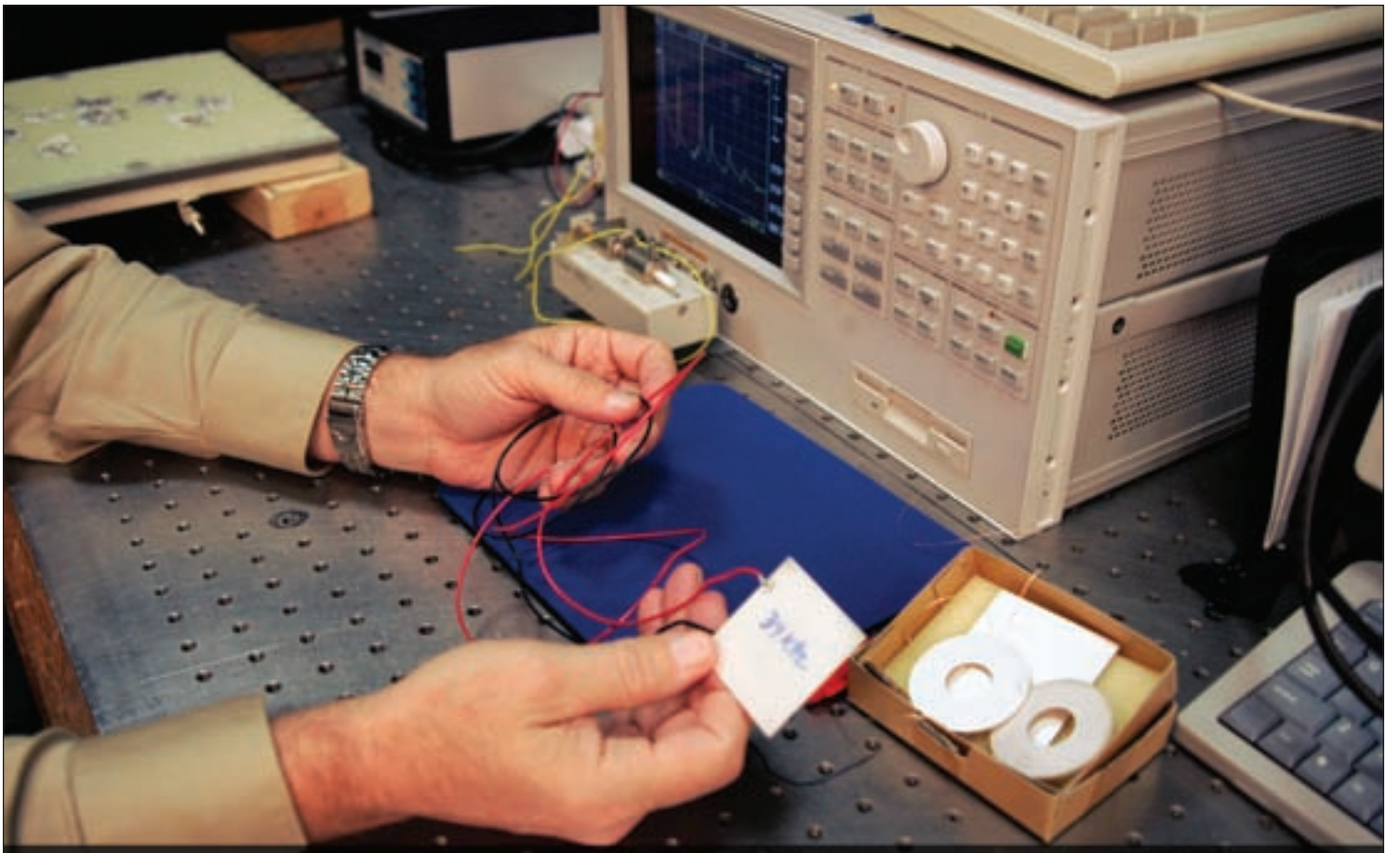
Piezoelectric lead zirconate titanate transducers are used to distinguish modes of vibration in plates to indicate plate damage. The amplitudes from the vibration spectrum are compared among damaged and undamaged vehicle plates.

TARDEC started using bonded sensors for ultrasonic crack detection on body armor plates and extended the technique to various types of composite armors used on ground vehicles. In-house NDE techniques are used to calibrate

TARDEC Research Scientist Dr. Thomas J. Meitzler adjusts an oscilloscope in his laboratory. The oscilloscope lets researchers see the varying voltages that each armor plate produces in wave form. If varying wave forms are detected, researchers know the armor is damaged. (U.S. Army TARDEC photo by Bill Dowell.)



Various transducers are being tested to find the best result for detecting cracks in embedded armor. (U.S. Army TARDEC photo by Bill Dowell.)

sensors embedded in armor for crack detection and health monitoring.

TARDEC and ARL are working together to determine how various cracks and defects affect ballistic armor performance. This information can then be given to commanders to better know when to replace armor panels and indicate what missions are possible given the armor condition.

"There is value in pursuing this technology because it allows vehicles being engaged to know the status of the vehicle's armor," explained TARDEC's MAJ Larry Ross. "This is especially true of smart armor that is taking multiple hits. You may know you took a couple rounds — but with this technology you know when you've taken a round too many."

Future work will concentrate on creating hand-held devices that are usable in the field to detect cracks and defects in armor, since the amenities of the laboratory are not readily available there.

An active NDE system can be used as a vehicle health monitoring system to tell the commander of vulnerabilities, what areas need repair, and what areas can stay in battle. The NDE can also be done at the depot level to assess armor integrity between missions to test armor defects or flaws as well as internal damage that can lead to armor failure. Knowing the severity of defects helps commanders monitor the armor's life cycle.

Future work will concentrate on creating hand-held devices that are usable in the field to detect cracks and defects in armor, since the amenities of the laboratory are not readily available there. TARDEC is working with local industry, academia, and other small companies to develop this technology.

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