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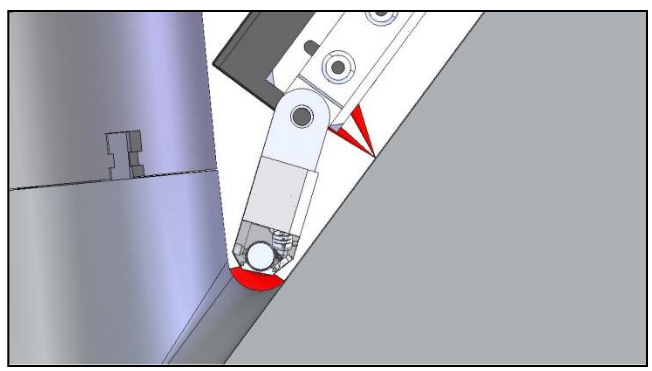
Laser Systems Could Provide Quicker, More Accurate Alternative for Surface Inspections

Successful proof-of-concept demonstration for crack detection on contoured surfaces has prompted EPRI to integrate the laser system with an inspection manipulator used for in-service examinations of reactor vessel upper heads.

EPRI's Nondestructive Evaluation Program is examining the use of laser systems to inspect surfaces susceptible to cracking, including bottom-mounted nozzles and control rod drive mechanism nozzles. Such systems could reduce the likelihood of false positives that have occurred using other inspection techniques, including ultrasonics and eddy current. It could also reduce the time and personnel radiation exposure associated with other surface inspection methods, such as liquid penetrant, which is performed manually.

Although lasers have been applied for years to make profile measurements in complex geometries, their use for flaw detection has been limited by their inability to detect very tight cracks and by the size of the laser scanning sensors. Technological advances in the development of detection algorithms and physically smaller laser systems have addressed these limitations. EPRI performed a feasibility study to determine if lasers could be used to detect stress corrosion cracking flaws with crack opening widths as small as 10 to 150 microns (0.0004 inches to 0.006 inches). As a point of comparison, human hair is 40-60 microns in diameter. Using samples with artificially fabricated flaws, the laser system detected flaws with widths as small as 0.001 inch.

These results prompted EPRI to develop a robotic delivery device and surface-scanning sensor for inspecting J-groove welds (see figure) on reactor vessel upper head control rod drive mechanism (CRDM) nozzles to detect surface cracks associated with primary water stress corrosion cracking. Demonstration on such contoured weld surfaces was necessary because the previous proof-of-concept work had been conducted on flat coupons. The project included developing a compact scanning sensor, a four-axis manipulator delivery system, a laser sensor to monitor the stand-off distance of the scanning sensor, and an electronic interface for remote operation of the delivery system.



Sensor scanning a control rod drive mechanism nozzle

EPRI fabricated CRDM mockups with known flaws to evaluate the capabilities of the laser-scanning sensor system. The laser-scanning sensor – using a fundamentally new design that incorporates a rotating mirror to enable faster two-dimensional scanning – successfully detected manufactured flaws in the contoured surface of the J-groove weld as small as 0.001 inches wide by 0.41 inches long. The robotic delivery device successfully moved the sensor around the surface for scanning, and software successfully controlled the four axes of motion and the height of the sensor above the surface (using an automatic distance control feedback loop).

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