Title

Real-Time Neutron Radiography - Applications For The Automotive Industry

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Real-Time Neutron Radiography Applications For The Automotive Industry

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Facility Description

The McClellan Nuclear Radiation Center's neutron source is a 2 MW TRIGA-type research reactor. The reactor operates 24 hours per day, five days per week accomplishing a wide variety of irradiation services. These services include isotope production, silicon doping and a wide variety of neutron radiography projects.

The reactor facility includes five neutron beams supplying five bays configured radially around the reactor (Figure 1). In bays one and two, robotically controlled component positioning systems manipulate components in the neutron beam during radioscopic inspections. These two bays are also film radiography capable. Bay three is equipped with a remotely controlled, joy stick operated, component positioning table. Although this bay is currently dedicated to thermal neutron computed tomography, it is also radioscopic inspection and film radiography capable. Bay four is used for direct and indirect film radiography and experimental neutron beam work. Bay five is the epithermal neutron beam used principally for medical work, but can also be used for resonance radiography work. [1,2,3,4]

Bay one is the largest radiography bay, measuring 71 ft long, 32 ft wide and 38 ft deep. It also houses the largest component positioning robot. Bay three is the smallest of the bays. It is 24 ft long, 20 ft wide, and 16 ft deep. Component size for this bay is further restricted by the size of the entry door.

The component positioning system robot in radiography bay one is the larger of the two robotic systems. With an inspection envelope of 32 ft x 12 ft and weighing 30 tons, components as large as an F-111 wing can be robotically scanned.

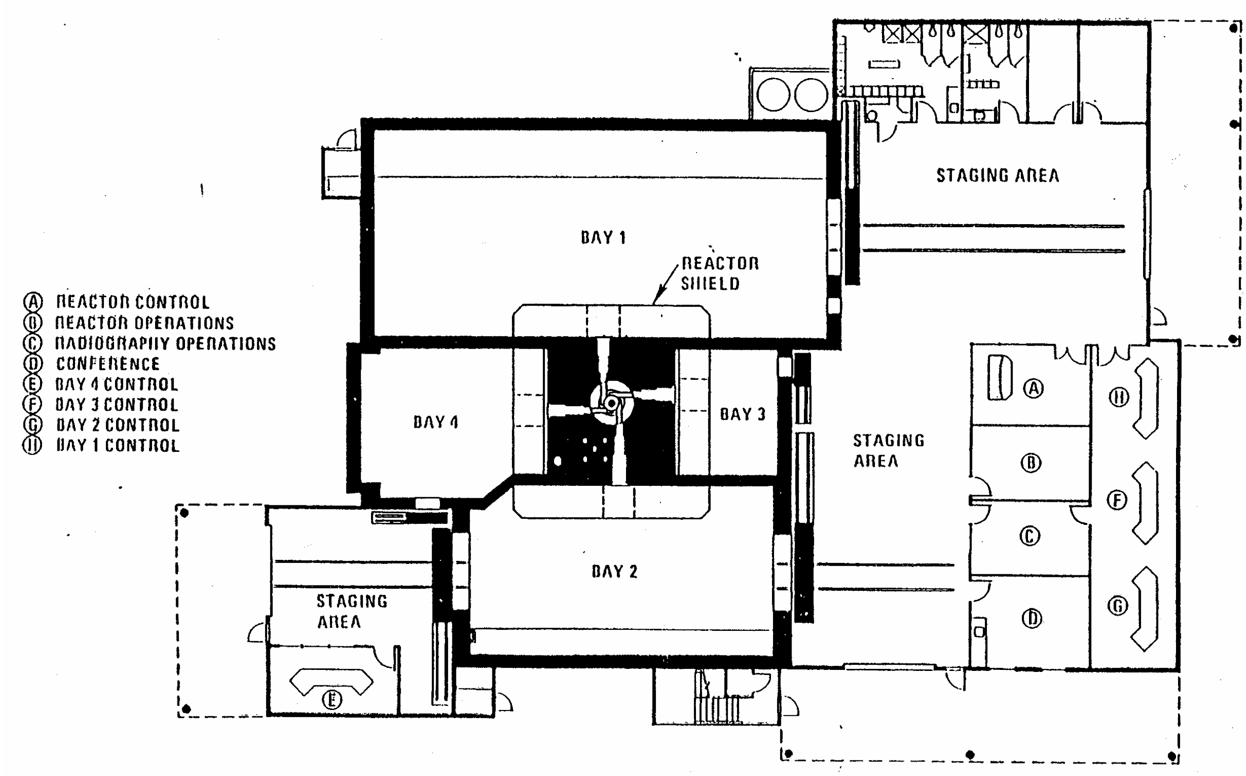

Figure 1

The neutron image intensifier and CCD camera are carried on an extended arm. A large area capacitance sensor is mounted on the front of the imager box and is used by the robotic system to keep the imager within .2 to 2.5 inches from the part being inspected (Figure 2).
Scanning of the parts is accomplished with preprogrammed scan plan based on and x, y, Cartesian coordinate system. Scan plans are programmed with scan lines every five inches to ensure overlapping coverage. Maximum scanning speed is two inches per second, while typical scan speed is one-half inch per second.

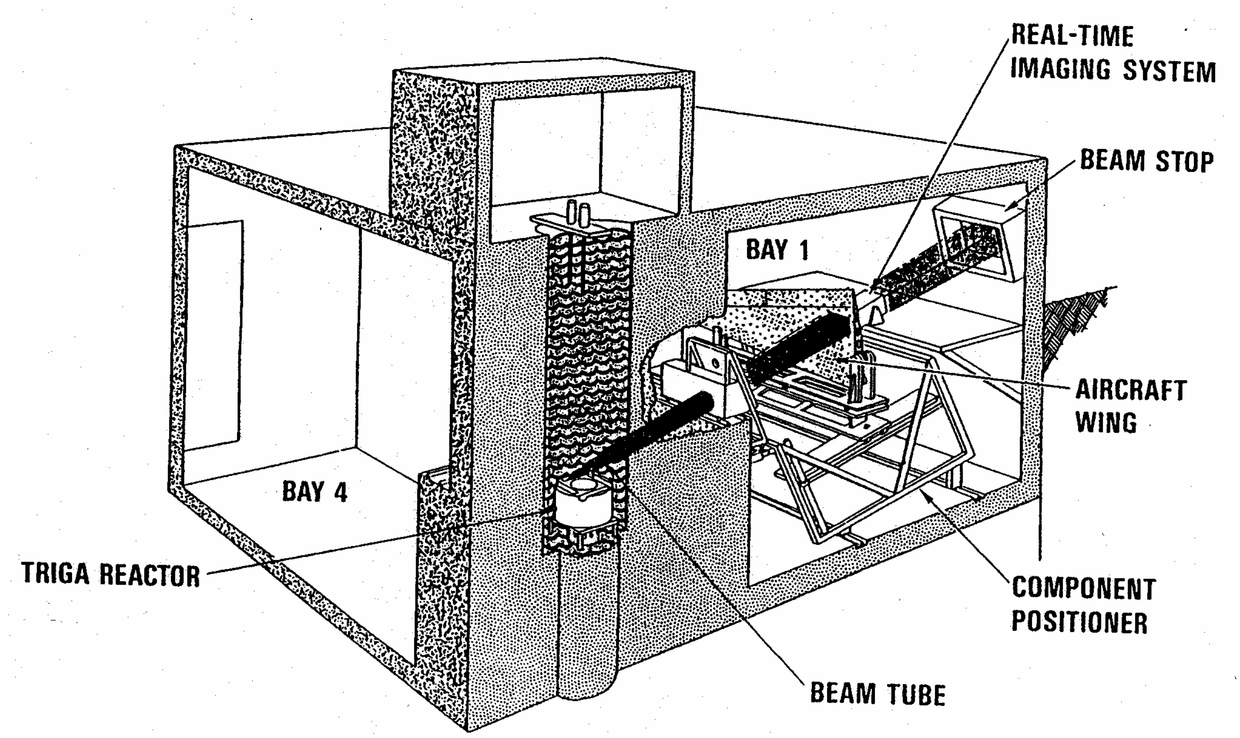

Figure 2

The radioscopic imaging systems use a Thompson CSF tri-field tube with an internal gadolinium-oxy sulfide scintillator, a 486 x 1134 pixel CCD camera, and a Datacube based image processing system. The tri-field imager allows for image fields-of-view of nine inches, six inches, and four and a half inches, which translates to 1x, 1.5x and 2x magnification respectively. The system allows image processing functions such as background subtraction, true averaging up to 2048 frames, recursive averaging up to 64 frames, contrast stretch, pseudocolor, edge enhancement, profiles, histograms, distance measurements, zoom and scroll.

Radioscopic imaging is 30 hertz real-time with two to four frame recursive averaging and background subtraction typical. Other image processing may be employed such as contrast stretch, filters, and pseudocolor, while still maintaining 30 frames per second. Inspection imaging is accomplished at L/D = 100, with capabilities ranging from L/D = 92 to L/D = 112.

The entire inspection is recorded on Extended Definition Beta (E.D. Beta) magnetic tape. Images identifying component defects are also digitally stored on two G-byte optical disks for archiving and possible future reprocessing. Hard copy prints of the defect areas are generated for customer use.

Since production began in 1990, approximately 8000 components have been radioscopically inspected using the reactor's radioscopic systems.

Automotive Applications

Even though the radioscopic system have been primarily used for aircraft inspections, recent legislation that allows DOD facilities to work on commercial projects, has resulted in using the large component capability for automotive applications.

Using neutron radioscopic techniques for the automotive industry is not new [5]. The truly unique feature the MNRC offers is the large beam size (i.e., nine inches in diameter), and the ability to handle large components (i.e., whole engine or transmission trains) in the beam with very accurate positioning.

A number of interesting projects have been proposed; from looking at an operating engine to watch the combustion process, observing oil moving from the crankcase to the top of the engine, to looking at the operation of solenoid valves in brake systems under operating conditions.

A recent project involved working with a transmission cooler at various fluid pressures (Fig 3). The radioscopic images clearly show the fill rates and patterns for various pressures and structure orientations. Of considerable interest was the threshold pressure for the onset of turbulent flow and a strong venturi action to appear. These results clearly show how valuable neutron radioscopic inspections can be for certain engineering problems. In addition, inspections have been particularly helpful in validating the engineering model being used. A closely associated project was the operations of solenoid valves in brake systems (Figure 4). Again the radioscopic inspection systems show the rate of change from open to closed, and the flow patterns caused by such movements. These dynamic events can then be used to confirm system performance and observed readings (i.e., pressure, temperature and volume fill rates).

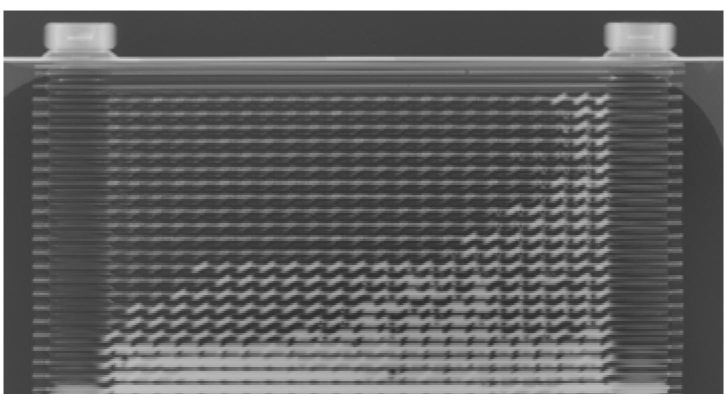

Figure 3 Transmission Oil Cooler

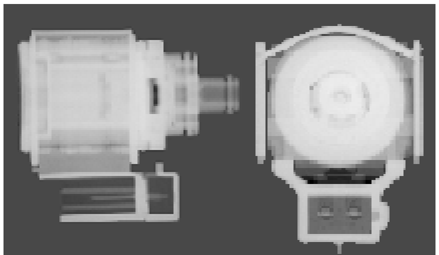

Figure 4 Electric Solenoid Valve

The MNRC radioscopic systems have demonstrated their ability to provide important information in the aircraft inspection process. With the new legislation allowing DOD facilities to perform commercial work, these unique inspection tools can be used to assist the automotive industry in new and creative ways.

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