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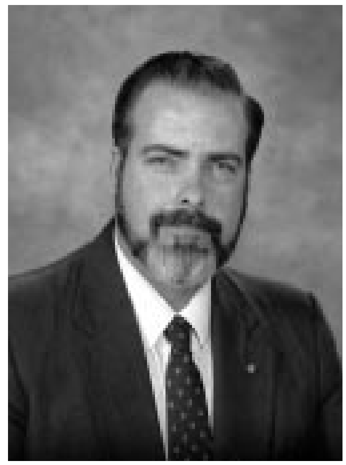
Twenty-fifth Annual Review of Progress Planned for July 19–24,1998

The Annual Review of Progress in Quantitative Nondestructive Evaluation (NDE) will be held at the Snowbird Ski and Conference Center, Snowbird, Utah, July 19–24, 1998. This will be the twenty-fifth review in this long-standing series known for its quality of presentation of both advanced NDE research and application results.



John Malone, PhD

Jean Bussière, PhD

The Review is designed to enhance communication and transfer of results between the research and engineering communities and to provide information to the NDE community as to future directions and evolution of the field. As such, the Review encourages attendance by researchers, engineers, practitioners, and students. A comprehensive technical program is planned that consists of leading edge keynote and plenary sessions, organized and contributed sessions, and two sessions celebrating the contributions and memories of Professor Otto Buck and John Moulder, members of CNDE who passed away during the past year. Both verbal and poster sessions are included.

This year's keynote talk will focus on the development of the National Aeronautics and Space Administration's new paradigm for engineering system development and the inclusion of an intelligent NDE technology that can simulate the total life cycle of the system. John Malone, PhD and deputy director for the Research and Technology Group at the NASA Langley Research Center, will provide a vision of this advanced technology as the opening speaker of the conference on Monday morning, July 20. Coauthors include J. Housner, PhD, and E. Generazio, PhD, from NASA Langley.

In his talk titled "The Intelligent Synthesis Environment: A NASA Concept for the Engineering Design of Aerospace Systems in the Twenty-First Century," Malone will discuss a new NASA version for an intelligent synthesis environment concept (ISE) that will provide a capability for modeling all aspects of the design, manufacture, and operation of an aerospace component or system. In this "cradle to grave" virtual reality environment, the system's total life cycle will be simulated starting with system design and ending with disposal. The paper will suggest ways in which NDE models and simulations will form a part of this life cycle paradigm and, thus, contribute to improving cost-effectiveness as well as safety.

Two well-known NDE contributors will provide related plenary talks following the keynote address.

In the first of these, Jean Bussière, PhD, of the Industrial Materials Research Institute, National Research

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Inside

CNDE News is published twice each year by the Center for Nondestructive Evaluation. CNDE is a member of the Institute for Physical Research and Technology at Iowa State University.
Designer: Janice Weedman
Editors: Linda Poore
Anita Rollins

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Council–Canada, will highlight an important role of NDE in one sector of ISE, i.e., the process control of agile, intelligent manufacturing. In his talk, Bussière will review recent developments in sensor technologies. He will also define unmet needs for sensors that measure critical parameters during production and how the use of these sensors can result in significant improvements in process understanding, control, and productivity. Bussière is currently director of the Process Instrumentation section of the Industrial Materials Research Institute.

Robert Shannon

To conclude the opening plenary session, Robert Shannon of the Westinghouse Science and Technology Center will discuss "Intelligent Design for NDE—An Engineering Challenge," which is another key aspect of ISE.

Shannon will discuss examples of advances in NDE technology and simulations made in recent years that contribute to the full economic life cycle of components and systems. These examples will include simulations of NDE processes and demonstration models/simulations that are useful industrially for manufacturing and service needs. His talk will also present a challenge—how to make NDE technology developments an effective contributor to ISE.

Tom Siewert

A final plenary session will be held on Wednesday evening, July 21. In this session, Tom Siewert, PhD, assisted by Chris Fortunko, PhD, of the National Institute of Standards and Technology will provide a discussion of "The International Standards System and NDE," an extremely timely subject for NDE practitioners.

The globalization of industry (manufacturing, construction, services, etc.) is increasing the possibility that a company will be required to inspect products according to unfamiliar standards and procedures. A key theme of the talk will be to provide NDE researchers and practitioners with a heads-up as to how these developments may impact their work and how standards considerations may be drawn into an intelligent environment. Siewert will review current developments in the International Organization for Standardization (ISO), ISO 9000, the system of weld inspection standards that it creates, and technical issues related to revising the standards. Discussion will also focus on demonstrating how some of the technical issues regarding harmonization of national and international

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Speaker Biographies

John Malone
Present position: Deputy Director, Research and Technology Group, National Aeronautics and Space Administration Langley Research Center, Hampton, Virginia
Responsibilities: Implementation of major research and development (R&D) program in aerodynamics, fluid mechanics, gas dynamics, acoustics, structures, materials, flight dynamics and controls, and flight electronics.
Experience: Researched experimental aerodynamics, aeroelasticity, and aeroacoustics; computational methods development for aerodynamic, structural dynamic, and aeroelastic analysis; and development of computational methods in aerodynamic and structural design.
Previous positions: Chief of Structural Mechanics and Head of Unsteady Aerodynamics, Structural Dynamics Division, NASA Langley Research Center; Grumman Aerospace Corp.; Lockheed-Georgia Co.; and Bell Helicopter Textron Inc.
Education: PhD, Aerospace Engineering, Georgia Institute of Technology, 1974

Jean Bussière
Present position: Director of Process Instrumentation, Industrial Materials Research Institute, Boucherville, Quebec
Responsibilities: Research of nondestructive methods to remotely and/or noninvasively characterize the microstructure and behavior of materials during processing
Experience: Investigated superconducting and structural materials for use in power transmission cables; author of over one hundred technical papers; holder of eight patents; editorial board member of the *Journal of Research in Nondestructive Evaluation, International Advances in Nondestructive Testing, Journal of the Canadian Society of Nondestructive Testing;* organizer of Nondestructive Evaluation and Sensors for process control workshops and on symposia
Previous positions: Brookhaven National Laboratory
Education: PhD, Physics, University of Ottawa, 1973

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standards might be resolved using an ultrasonic calibration block.

In addition to the plenary sessions, both organized and contributed verbal sessions will provide a broad coverage of progress in the development of all quantitative NDE technologies and their application to various system and materials problems. Materials of interest include homogeneous materials and specially engineered materials (composites, processed materials, etc.) for various applications. The poster sessions provide an excellent opportunity for one-on-one discussions between the audience and the author(s).

Finally, and by no means least, memorial sessions are planned to honor the scientific contributions of Professor Otto Buck and John Moulder, both members of CNDE who passed away this past year. Buck was well-known for his many contributions to metal physics and the development and utilization of NDE techniques to characterize metallic materials. Moulder was known world-wide for his many innovative contributions to eddy current technology. Friends and former students of Professor Buck and Moulder are invited to attend.

For questions regarding registration for the Review, please contact: Judy Johnson at 515/294-5474 or judyj@cnde.iastate.edu. Registration forms and further information can be found at the QNDE web site at http://www.cnde.iastate.edu/qnde/qnde.html.—*Donald Thompson*

BIOGRAPHIES*/continued from page 2*

Robert Shannon
Present position: Director of the corporate-sponsored NDE Innovation Center Program, Westinghouse Science and Technology Center, Pittsburgh, Pennsylvania
Responsibilities: Applied nondestructive evaluation techniques in a variety of situations, including research programs that develop NDE modeling techniques for application in the full life-cycle of engineering components
Experience: Chairman of the Technology Transfer Committee of the American Society of Nondestructive Testing (ASNT); director of the ASNT Pittsburgh Section; member of the Industrial Advisory Committee for the National Institute of Standards and Technology; winner of nine US patents important to power generation, nuclear fuel, and environmental businesses
Education: BS, metallurgical engineering, Purdue, 1972; MS, materials science, Northwestern University, 1974

Tom Siewert
Present position: Supervisory Metallurgist and Leader of the Structural Materials group, National Institute of Standards and Technology, and Adjunct Professor, Metallurgical and Materials Engineering Department, Colorado School of Mines, Boulder, Colorado
Responsibilities: In addition to those responsibilities associated with his work at NIST and Colorado School of Mines, he teaches short courses around the country on NDE, welding, and materials
Experience: Active on various national and international bodies, including the International Institute of Welding (IIW), chairman of its Commission V (NDE) and chairman of the American Council; invited lecturer to international conferences; registered professional engineer; author of over 100 technical papers in NDE, metallurgy and welding processes; patent holder on weld sensing, welding consumable, and NDE sensing technologies; elected fellow and honorary member of the American Welding Society; elected to Sigma Xi, Phi Kappa Phi, and Alpha Sigma Mu
Previous positions: Supervisory research engineer, then Manager of research and development, Alloy Rods
Education: BS and MS, applied math and physics, University of Wisconsin-Milwaukee, 1969 and 1970; PhD metallurgical engineering, University of Wisconsin-Milwaukee, 1976

Titanium Defect Research Progressing

Scientists at CNDE are completing a critical first step in the process of determining the detectability of naturally occurring defects in the titanium alloys used to manufacture aircraft engines. Researcher Chien-Ping Chiou and graduate student Brian Boyd, under the direction of CNDE Director Bruce Thompson, are taking a new approach to bring geometrical and ultrasonic models together for the Engine Titanium Consortium (ETC).

The ETC is an FAA-supported consortium involving AlliedSignal, General Electric, and Pratt & Whitney that is facilitated by Iowa State University. The ETC has as its goal to improve detection of engine defects, such as the hard-alpha inclusions that were identified as the cause of the 1989 United Airlines DC-10 aircraft crash in Sioux City, Iowa.

Detecting defects in titanium alloys is a difficult task. “Ultrasonically, the alloys are very noisy,” said Chiou. The microstructures of the titanium alloys are naturally inhomogeneous and reflect high-level ultrasonic energy back to the interrogating transducer. This causes misleading readings during inspection. To address this, ETC is developing improved techniques for the detection of the hard-alpha inclusions in both production and service environments, as well as improved methods for evaluation of the improvements in the detection capabilities afforded by these techniques.

The latter information, quantified by a quality known as the probability of detection (POD), is often combined with information concerning the rate of crack growth in the management of the lives of the aircraft. This assessment of detection capability has been made difficult by the paucity of naturally-occurring hard-alpha inclusions, a situation that is good news for the flying public but that makes it difficult to conduct experimental programs to quantify detectability. Such programs generally require a large number of nearly identical defects that can be analyzed by statistical techniques in order to determine such figures of merit as POD.

“That’s why models are needed,” said Chiou, “They will allow us to assess those situations that may be otherwise unfeasible and to do so much more cost-effectively.”

Model simulations can be used to examine the effect of flaw morphology on the ultrasonic signals in minimal turn-around time and to extract the maximum amount of information from the limited number of naturally occurring flaws that are available for examination. Using the results of geometric models and other supplemental analyses, the geometrical and material properties of the hard alpha defects can be promptly obtained to drive the ultrasonic model calculations and, ultimately, the POD evaluation.

An important phase in the validation of this approach began two years ago when a power failure caused a heat of titanium to be produced that contained many hard-alpha inclusions. The properties of these inclusions were judged to be similar to those occasionally found in normal production procedures. This provided an opportunity to gather experimental data that would define the response of naturally-occurring defects whose detailed morphology and composition could then be obtained by metallurgical analysis. This data could later be used both in direct estimates of detectability for the few flaws examined in this way and in validating the models needed to generalize this information. To this end, a methodology has been developed by CNDE in collaboration with ISU’s statistics department and a team of industrial researchers from ETC.

As a first step, with guidance and funding from the ETC, 12 “dirty” or defective billets were purchased. The billets, 10 feet long and 6 inches in diameter, can be considered cylindrical preforms for the fabrication of the rotating components of engines. Using the multizone inspection system developed under the leadership of General Electric, the billets were ultrasonically inspected and 60 defects were identified. The use of a phased array inspection also led to the detection of over 60 defects, which caused the team to believe that both ultrasonic approaches have similar detectability capabilities. Ten of the indications were then chosen as representative sample defects for the purposes identified.

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The main work then began of isolating and cutting cubes from the billets that contained the defects to be studied. Both A-scans and C-scans were completed for each sample, then metallographic cross-section images were taken to fully define the defects and provide inputs to a geometric

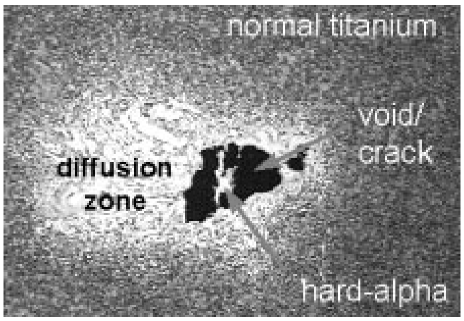

Fig. 1

model. The metallographs were formed by grinding off part of the sample surface at small, even intervals and then taking photos through an optical microscope.

Figure 1 shows one such metallographic image depicting the various components of a typical hard-alpha defect. “What the study found confirmed the commonly held expectation that cracks and voids, created as the brittle hard-alpha material fractured during the manufacturing process or during inservice use, produce larger ultrasonic responses that make them easier to detect than pure hard alpha inclusions,” said Chiou.

Based on the metallographic images, the defect geometries were reconstructed by Chiou’s team. Figures 2–5 provide an example of the reconstruction of the core of the hard alpha inclusion.

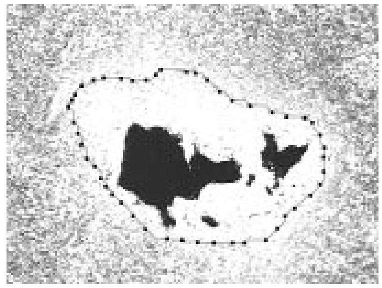

Fig. 2

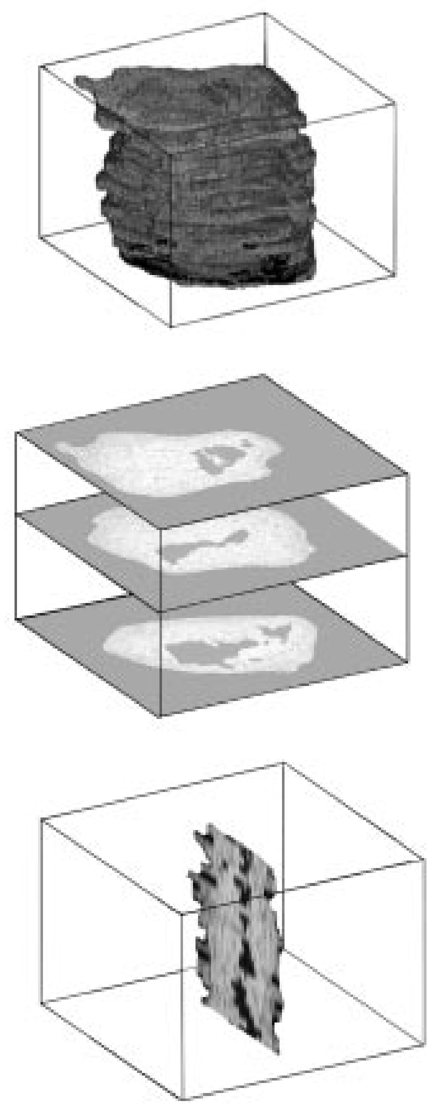

Fig. 3–5

The process began with a defect boundary trace, which was manually drawn to define a region of interest in a metallographic image (Figure 2). A linear pixel interpolation followed to connect the traced boundary points by a closed loop. Next, the interpolated boundary loops were normalized to a common number of line segments specified for all metallographic images. After the same boundary determination procedure was applied to each of the images, a three-dimensional solid model was constructed (Figure 3) using a bilinear interpolation scheme for each successive image slice (Figure 4). This approach allows the solid model to be sliced apart at any orientation to

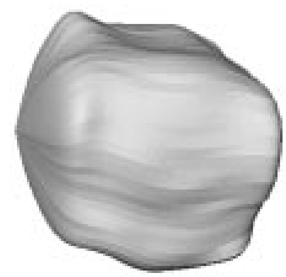

Fig. 6

analyze the interior of the defect as shown in Figure 5. Shown in Figure 6 is a smoothed surface model using the same manual boundary traces with the Bezier interpolation scheme.

Other important practical issues are also addressed in the processes of grinding and reconstruction. For example, to ensure the accuracy of the ultrasonic model, proper ratios between the ultrasonic wavelength, grinding interval, and the mesh size of geometrical models were all carefully maintained.

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Most currently the effort is focused on modeling the void and crack portions of the hard-alpha defects since these, rather than the core, usually dominate the ultrasonic responses from the defects, as was mentioned. Figure 7 depicts a surface model of the voids constructed for the first of the ten representative sample defects. For the 11 void parts, 15,193 geometrical coordinates and 30,342 surface elements were identified. The model was created using the state-of-the-art nonuniform rational B-spline technique (NURBS), which enables interpolation between the gaps of the existing slice data as well as extrapolation toward the ends of the void regions where no further information is available. Several image processing algorithms were also developed for autonomous extraction of the flaw boundary from the metallographs.

In addition to reconstructing the defect geometries, ultrasonic models were developed. They were derived from the Thompson-Gray measurement model framework previously developed by CNDE's Bruce Thompson and Tim Gray. The main advantage of this framework over other methodologies is a reduction in computation effort while maintaining commendable modeling accuracy.

In current work, two new lines of models have been developed for flaws of inclusion and void/crack types. For inclusions, a volumetric formulation was devised using the long-wavelength Born approximation and a three-dimensional integration scheme. For voids and cracks, a surface model utilizing the high frequency Kirchhoff approximation with a two-dimensional surface integration was obtained. In both models, the integration is carried out numerically using the geometrical information provided by the geometrical models.

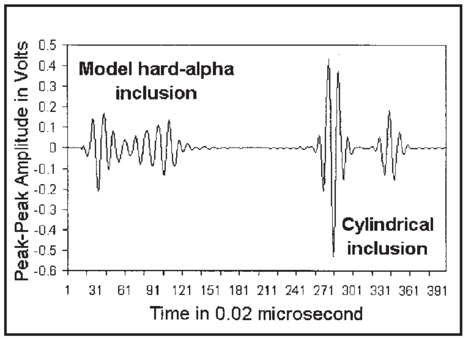

Fig. 8

"To our best knowledge, this work is pretty unique," said Chiou. "Although the fundamental theories of ultrasonic modeling (including Born and Kirchhoff approximations) have appeared in the literature for many years, this would be the newest, if not the first, attempt to use this kind of approach at such a level of complexity."

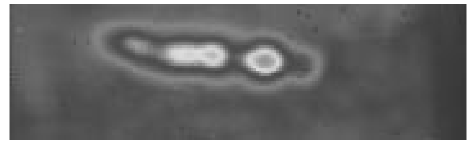

Fig. 9

To demonstrate the capability of the ultrasonic models, Figure 8 compares the A-scan model prediction for the geometry given by the Bezier model in Figure 6 with that of a cylindrical inclusion of equivalent size, both assuming the same acoustic properties and inspection scenario. As was expected, due to irregularities in shape, the returning echoes of the Bezier model cannot be resolved while those from the same size flaw in a cylindrical shape are well resolved. In addition, the peak amplitude predicted for the flaw by the Bezier model is significantly lower than the cylindrical counterpart, leading to poor detectability.

Rigorous validation of the ultrasonic models was then conducted using experimental data. Figure 9 plots the experimental 5 MHz C-scan image taken from the first of the

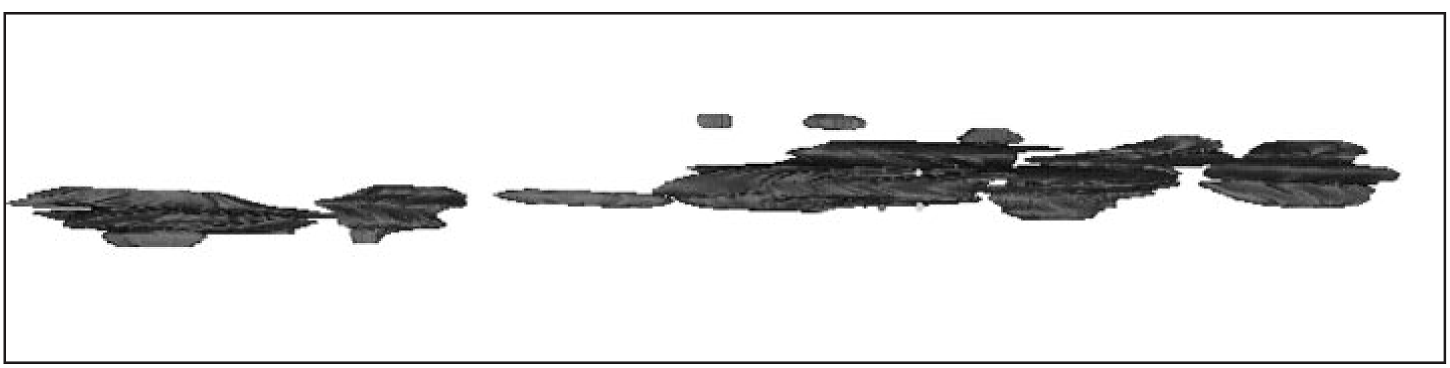

Fig. 7

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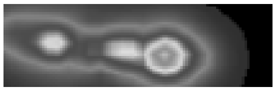

Fig. 10

representative hard-alpha samples before destructive sectioning, which can be directly compared with a simulated C-scan image generated from the ultrasonic model (Figure 10). It can be seen that the shape and orientation of the experimental C-scan images are in good agreement with the simulated C-scan image. In fact, for this preliminary case, the ultrasonic model has achieved an absolute accuracy of 6-dB in predicting the peak amplitude in C-scan inspections, a result that is very encouraging as a first attempt.

The ability of modeling real flaws will permit simulation of a variety of realistic inspection scenarios and rapidly generate predictions of ultrasonic signals. By obtaining information on a flaw under certain scanning conditions, researchers at ISU hope that POD information can result. To complete the POD step of the task, statistics professor William Meeker will use a physical/statistical prediction model to forecast NDE capability in terms of POD, probability of false alarm, probability of indication, and receiver operating characteristic curves.

"Having just compared our predictions to experimental data on a few defects, we are still in the preliminary stages of our work," said Chiou, "but we are making good progress."*–Anita Rollins*

Schmerr Authors Book

Les Schmerr, CNDE associate director, is the author of a new book. *Fundamentals of Ultrasonic Nondestructive Evaluation—A Modeling Approach* will be released in July 1998.

This book is an outgrowth of a graduate level course, “Ultrasonic Nondestructive Measurement Principles,” that Schmerr developed and has taught for over 15 years at Iowa State University. The book has been five years in the making and is the first to detail the entire ultrasonic nondestructive evaluation (NDE) measurement process using models, including many methods and results coming from research at CNDE.

Schmerr is excited about the book becoming available. “It is an example of how modeling technology can be used to make NDE techniques better understood and more quantitative,” he said. “It’s an approach that has been a key research focus at the CNDE for many years in ultrasonics, as well as in other major NDE techniques such as x-rays, eddy currents, and magnetics.”

The book is being released by Plenum Publishing Company.

Industrial Visitor Investigates NDE Approaches

Yohan Rew of Samsung Heavy Industries visited CNDE for a week in November 1997. Rew came to investigate nondestructive testing methods and approaches for a filament-wound composite driveshaft that Samsung was developing. He conducted squirter and immersion tests with ultrasound on Samsung samples and obtained useful results.

Yohan Rew of Samsung Heavy Industries conducting ultrasonic measurements in the composite nondestructive evaluation laboratory at CNDE.

Research Aboard Ice-bound Ship Will Provide Key Data on Polar Clouds

Jim Liljegren, a CNDE and US Department of Energy (DOE) Ames Laboratory scientist, will soon find out what it's like to live on thin ice.

Liljegren, an atmospheric researcher, is spending May 13–June 23 on the Des Groseilliers, a Canadian icebreaker that was frozen into the ice last September as part of a 13-month mission to study the arctic's role in relation to global climate change. The ship is currently about 400 miles north of Barrow, Alaska, and is drifting west with the ice pack.

"I'm eager to go because, as an experimentalist, it really helps to go to the field and actually be there as the data are collected so that you get a reality check rather than simply being an armchair commando," said Liljegren, who will be gathering data about polar clouds.

The research being conducted on the ship is a vital component of a five-year, international project known as the Surface Heat Budget of the Arctic Ocean (SHEBA) aimed at providing scientists with a better understanding of polar climates and how global change affects them. Among the participants in SHEBA is the DOE's Atmospheric Radiation Measurement (ARM) Program, a broad-based effort to develop better models for predicting the effect of clouds on the Earth's climate.

For the past six years, Liljegren has been responsible for ARM's microwave radiometers— instruments that measure the amount of water vapor and liquid water in clouds. One of the ARM radiometers is on the ice pack to gather much-needed data about the nature of polar clouds.

Jim Liljegren

"Polar clouds are considerably different from what you find at midlatitudes and aren't anything like what you typically find in the tropics," Liljegren said. "Because of the remoteness of the arctic, the data on polar clouds has been extremely limited." Clouds play a dual role in the climate models since they help trap heat in the atmosphere as well as deflect energy from the sun.

The polar regions are viewed as key areas in determining the possible effects of global warming. Because the poles are sensitive regions, the effects of global climate change are likely to be noticed there first. "If the climate models don't treat the processes near the arctic very well, then their estimate of the impact of global warming may be incorrect," he said.

Scientists who have equipment aboard the icebreaker and on the surrounding ice pack have been scheduled for rotating shifts there. Because Liljegren wanted to see the clouds his equipment is measuring, he chose to go during the late spring when the sun is up continuously.

"Cloud models are very complicated and very sophisticated, but all of that sophistication cannot be put into these large climate models, and the large models have somewhat oversimplified how clouds form and what effect clouds have on the radiative balance," Liljegren said. "My area of research is to try to improve that state of affairs."

One of Liljegren's planned improvements is rewriting software to enable the radiometer to measure more quickly, thus improving coordination between the radiometers and ARM's new cloud radars. He is also developing an algorithm that combines infrared measurements of cloud temperature with microwave measurements in order to determine the liquid water content of clouds more accurately than the current algorithm, which uses microwave measurements alone.

What excites Liljegren about climate research is the ability to look at how the components— ocean, atmosphere and land—relate to each other. "Most of science seeks to break things down into finer and finer elements so that you understand the details of that element really, really well," he explained. "The focus in climate research is on the interactions among the different elements and how a change in one affects the others. You really get to see that the global climate system is just that—a system."–*Susan Dieterle*

CNDE Working to Increase the Harvest

Farmers have always had a rich resource for agricultural research information in Iowa State University. Now ISU's CNDE and the US Department of Energy's Ames Laboratory are teaming up to take farming into the twenty-first century.

With the introduction of global positioning technology that can provide coordinates for any point on the land, precision farming—a concept that requires farming practices to be based upon extensive database research—became technically feasible. The ultimate goal of precision farming is to optimize crop yield and reduce environmental contamination by allowing farmers to make adjustments to planting, harvesting, or fertilizing operations based on scientific data. But collecting the information about applications, weather conditions, physical treatment of the land, and grain yield requires a mapping system.

With funding from Ames Laboratory through its Applied NDE program, and using the CNDE x-ray facilities, Feyzi Inanc and Joseph Gray are working on the grain yield portion of that system. The team is investigating the use of an x-ray technique to monitor yield during harvesting of corn.

X-rays are commonly used by industry for material thickness gauging. Using this approach the team sends a low energy x-ray beam across the grain as it flows from one container to another. An image intensifier opposite the generator then picks up the resulting image and expresses the information in gray scale values, which look much like fuzzy, old black and white television images. These gray scale values are then correlated to the amount of material being x-rayed, permitting an accurate, on-the-spot measurement of grain yield.

Inanc said that because the produce analyzed is exposed to low level x-rays for a fraction of a second, it is not harmful. In fact, the generator proposed for use would only require lead shielding with a thickness of 1-2 mm.

The proposed real-time yield monitoring system has several key advantages, according to Inanc: 1) the flowing grain would not physically interact with the sensor surface, 2) the technique has a wide dynamic range not requiring frequent calibrations when yield changes, 3) x-ray investigation is more sensitive than current commercial sensing methods, and 4) x-ray measurements are relatively insensitive to varying grain moisture.

To further the research, both static and dynamic tests were conducted. In the static tests, samples with various known thickness values were prepared using corn kernels, which were placed on a sample holder. Gray scale values acquired from the tests were plotted as a function of sample thicknesses for determining dynamic range of the x-ray technique. Film radiography was also used, and the resulting image was digitized and analyzed. The static tests showed that the x-ray technique provides a very large dynamic range that could be used for a large regime of grain flow rates with the same settings.

In the dynamic tests, corn flowed from a gravity box into a collection container at various flow rates. Simulated flow rates in the laboratory were comparable to those encountered in field conditions using a popular combine at ISU's Agricultural Engineering Research Center.

Although there are commercially available devices that map yield, "the research shows that they are unstable and can be effected by operating conditions," said Inanc. As a result, now that the x-ray yield monitor concept has been proven the group is locating funding to build and mount a device on a combine for continuous operation.

"We still have a few issues to consider though," said Inanc. "The cost of the equipment must be at a level that is commercially competitive, for instance. We also need to do some engineering work—figuring out how to mount the device to the harvester and looking at issues such as mechanical vibration, x-ray shielding, dust isolation, powering, and cooling."

Inanc said the technology, once developed, will be easily modifiable for use with other crops as well. For more information, contact Inanc at 515/294-9738–*Anita Rollins*

Founder's Prize Winners for 1997–98

Chad Spore

Chad Spore and Benjamin Van Zante are the 1997–98 CNDE Founder's Prize winners. Each received a $1,500 scholarship to help complete undergraduate degrees at Iowa State University.

Spore is a junior in metallurgical engineering. A native of Muscatine, Iowa, he has been working on magnesium-neodymium castings and directional solidification of tin-cadmium. Spore plans to do an internship with John Deere this summer.

Van Zante is a junior in materials science and engineering with an emphasis in ceramic engineering and a minor in nondestructive evaluation. The Pella, Iowa, native has worked in silicide processing at the US Department of Energy's Ames Laboratory while learning about NDE techniques and defect management at Texas Instruments. Van Zante will work with castings applications at John Deere in Waterloo this summer. His long-term goal is to obtain a master's degree in materials science.

Benjamin Van Zante

The CNDE Founder's Prize was created in April 1995 and is supported by CNDE alumni, friends, and industrial partners. Winners are chosen from ISU juniors with a declared minor in NDE who have demonstrated exceptional academic performance. Community college students transferring to ISU are included in the award pool. ■

Beissner Joins Staff of CNDE

R. E. Beissner, recently retired from Southwest Research Institute (SWRI), has joined the eddy current, optics, and thermal group of CNDE as a visiting professor while an international search is conducted to fill the position created by the untimely death of John Moulder.

Beissner has extensive experience in the eddy current area in both the industrial and contract research settings. He was educated as a physicist with a BA from St. Mary's University in San Antonio, Texas, and MA and PhD degrees from Texas Christian University in Ft. Worth.

Beissner spent 14 years in the laboratories of Westinghouse Corp. as a nuclear engineer and at General Dynamics as a nuclear physicist, where he worked on radiation transport and radiation effects and served as the leader of the transport theory group. In 1969 he joined the staff of SWRI. There he progressed to the position of institute scientist at his retirement in 1996. Research areas included Fourier optics, quantum theory of metals, and electromagnetic NDE. Relevant to the efforts at CNDE is his pioneering work in the area of pulsed eddy currents under the support of the Air Force Materials Laboratory. After his retirement, Beissner continued as a consultant at SWRI until coming to Ames in April 1998.

"We are very pleased to have someone of Bob's stature and experience to help us as we search for a permanent replacement for Moulder," said Bruce Thompson, director of CNDE. "We hope that this association will continue after that position is filled."

Beissner can be reached by phone at 515/294-9750, and by email at rebeissner@cnde.iastate.edu. ■

Graduate Assistantship Awarded

Dong Fei is the 1997–98 recipient of the nondestructive evaluation (NDE) graduate assistantship offered by the Institute for Physical Research and Technology (IPRT) and CNDE at Iowa State University.

Fei received both his BS and MS degrees in electronics from Nanjing University, People's Republic of China. He is currently working with CNDE's David Hsu in the aerospace engineering and engineering mechanics department. Fei is developing novel motorized azimuthal ultrasonic scanners as a part of a project to detect and characterize defects in composites.

Dong Fei

The NDE graduate assistantship is awarded to individuals whose personal qualifications, demonstrated motivation, and research interests are judged to exhibit the highest potential for benefiting US industry and NDE technology. Candidates must have a desire to pursue thesis research in an industrially relevant NDE topic. This assistantship carries a stipend of $18,000 over a twelve-month period, as well as a scholarship equal to one-half the resident tuition fees. The assistantship is renewable for up to three years.

Two previous winners, Changjiu Dang and Matthias Rudolph, are still being supported by IPRT assistantships. Both are working under the direction of Les Schmerr.

Compact Disc to Improve Inspector Training

To improve aviation safety inspector (ASI) training, CNDE has adapted a training course to a computer format.

The CD-ROM "Nondestructive Inspection for ASIs" was funded for development by the Federal Aviation Administration at the FAA Center for Aviation Systems Reliability (CASR). A course previously developed by CASR in cooperation with the FAA Nondestructive Inspection (NDI) Training Design Panel and currently offered at the FAA Academy was adapted for the CD component.

As development began, "We had to answer two questions early in the process," said Lisa Brasche, CASR program manager. "First, would this type of training program be as effective and useful as the traditional classroom approach and, second, would the computer-based training allow a larger audience to receive training?"

It appears that the answer to both questions has been yes, according to Anita Ousley, who is co-principal investigator on the project. The advantages reported so far include increased interaction by users, cost effectiveness, increased motivation, immediate feedback, control of lesson integrity, and flexibility—users can repeat or spend more time in a component. The CD course can also serve as a refresher course for ASIs.

Industrial input was solicited and changes made to the prototype before completion of the CD, which incorporates sound, video, animation, and other graphics. The training sections covered the same elements as the ASI classroom training: certification of NDI facilities, an NDI facilities checklist, and an introduction to common NDI techniques.

Five hundred of the computer discs were produced with the FAA funding. The CD was well accepted by the FAA Academy course administrator, according to Brasche, and inquiries have also come from community colleges, airline industry partners, and the US Navy.

For more information on the CD course, contact Brasche at 515/294-5227, or Ousley at 515/294-1690.

Helping CNDE Improve Science Education

Those who study education trends continue to sound the alarm—there is a decline in the number of students pursuing careers in science and physics. Funding from the National Aeronautics and Space Administration, distributed through the Iowa Space Grant Consortium (ISGC), is helping CNDE develop a program that could help reverse that trend.

CNDE researchers Anita Ousley and Brian Larson are developing the "Program for Integrating NDE Technologies as Applied in Aerospace into the High School Science Curriculum." The program for students in grades 9–12 was started with a seed grant of $10,000 and an educational activities grant of $1500 from the Consortium. CNDE began work on the project in February of this year.

The long term goals of the program include: 1) increasing enthusiasm for science and developing an awareness of how scientific principals play a critical role in daily life, 2) providing alternative, stimulating learning opportunities that enhance the high school physics curriculum and increase participation of students in aerospace and nondestructive evaluation (NDE) careers, 3) providing high school teachers with curriculum enhancements and professional development opportunities to improve science and physics learning, and 4) using NDE technology to help students develop a broader understanding of the link between scientific principles and reality by demonstrating how scientific theory works in real world applications.

To accomplish this challenging task, the project for the current year has three initiatives: developing an interactive compact disc (CD), visiting high school career fairs to promote NDE careers, and holding an Iowa science teacher workshop.

Three undergraduate students will work on the CD, which will engage high school students in experiments and simulations of magnetism. The goal of the CD project is to demonstrate the role of magnetism in NDE and its importance to everyday life by showing how NDE is used in aerospace initiatives. Five hundred of the CDs will be distributed to Iowa high schools when the project is complete.

The project also provides an opportunity for a female intern to work in a science laboratory environment during the summer. The student will be supported jointly by the ISGC funds and by the Program for Women in Science and Engineering at ISU.

Two of the high school career fair visits, which are the second program component, have already been made. Students conducted experiments and completed hands-on activities with portable NDE equipment. Brief presentations about careers and educational programs in NDE were also given. Two other visits are scheduled for this fall and the third program element, the teacher workshop, will be held this summer.

The workshop will feature opportunities for high school science and physics teachers to experiment with NDE techniques, obtain preliminary instructional materials, discover resources for creating their own materials, and learn about aerospace/aviation careers.

Although promoting careers in NDE and aeronautics is integral to the new program, "it will extend further," said Ousley. "We're increasing interest in learning about science and physics in general, thus promoting science careers at all levels—as technicians, engineers, scientists, physicists, and researchers."

All of the components are related to the National Standards for Math and Science, a new document providing guidelines to increase national competitiveness in these areas. Presently, additional support is being sought from the National Science Foundation and several private foundations. For more information about the program, contact Ousley at 515/294-1629.–*Anita Rollins*

Iowa State University and CNDE: Producing Tomorrow's Leaders

CNDE, in cooperation with several academic colleges at Iowa State University, educates and trains new scientists to take on the challenges of the twenty-first century. ISU students involved in nondestructive evaluation research contribute significantly to CNDE's goals. Some of our graduating students and their research abstracts, as provided by the students, are presented on the following pages.

Brian Boyd

MS, Spring 1998

Mechanical Engineering

"The Development and Application of Geometrical Models of Defects for Ultrasonic Nondestructive Evaluation in Aircraft Engine Alloys"

This thesis describes the development and application of geometrical models of defects for ultrasonic nondestructive evaluation in aircraft engine alloys. The major part of this work was conducted as part of the efforts of the Engine Titanium Consortium, which currently conducts an extensive study of the ultrasonic response and detectability of a number of naturally-occurring hard-alpha defects found in titanium billets. These naturally-occurring defects are highly irregular in shape and inhomogeneous in composition, and we would like to assess the extent to which their responses can be predicted by available ultrasonic scattering models. Three-dimensional geometrical (surface and solid) models of the hard-alpha defects are needed in order to obtain the geometrical and material properties to drive the ultrasonic model calculations and the subsequent probability-of-detection evaluation. These models are to be derived from metallographic cross-section images taken from destructive sectioning of the defect regions. The reconstruction of a defect begins with the boundary determination of the respective defect regions on each of the metallographs by utilizing some image processing algorithms. The three-dimensional geometrical model then follows by using the state-of-the-art nonuniform rational b-spline techniques. Once the geometrical models are constructed, the complete material properties can be interpolated within the volume or on the surface of the defects. In this thesis, the detailed procedures of defect reconstruction as an input to ultrasonic signal modeling will also be illustrated.

Advisors: Chien-Ping Chiou, R. Bruce Thompson, James Oliver

Hui Cao

MS, Fall 1998

Materials Science and Engineering

"Magnetic Barkhausen Effect for Nondestructive Evaluation"

In this paper, several signal processing methods are developed for the Magnetic Barkhausen signal. Some characteristic parameters are obtained from these signal processing methods. Two welded Cr-Mo steel samples are scanned by the Barkhausen effect, and a clear weld image is obtained by a root-mean-square measure of the Barkhausen signal. Six case-hardened steel samples with different case depths are also measured by the Barkhausen effect, and the relationship between the Barkhausen characteristic parameters and the case depth are built.

Advisor: David Jiles

Loren Faeth

PhD, Spring 1998

Industrial & Educational Technology

"Inferring Bread Doneness with Air-pulse/Ultrasonic Ranging Measurements of the Loaf Elastic Response"

This research marks the discovery of a method by which bread doneness may be determined based on the elastic properties of the loaf as it bakes. The purpose of the study was to determine if changes in bread characteristics could be determined by non-contact methods during baking and be used as the basis for improved control of the baking process. Current control of the process is based on temperature and dwell time, which are determined by experience, to produce a product that is approximately "done." There is no direct way to measure the property of interest, which is doneness. An ultrasonic measurement system was developed to quantify the response of the loaf to an external stimulus. The system is designed to be compatible with strapped bread pans in a standard traveling-tray commercial oven.

Advisor: Roger A. Smith

Shu Gao

MS, Fall 1997

Electrical and Computer Engineering

"Application of Morphological Filter for Defect Detection in Eddy Current Wheel Inspection Signal"

Commercial eddy current aircraft wheel inspection systems acquire data from a helical scan that is displayed on a strip chart. The hardware of the inspection system produces a narrow band signal that is sampled at a low sampling rate. This hardware limitation eliminates the spatial and spectral differences between defect and noise signals. Therefore, conventional linear filters are not effective in extracting the defect signals from the data.

This thesis study presents an adaptive morphological filter for defect detection in wheel inspection data. The helically scanned signal is first represented in image form, with each row corresponding to one revolution of the scan. The proposed system is a combination of two orthogonal one-dimensional morphological filters, one operating on row data to detect peaks from the residual signal, the second operating on column data evaluating the correlation between the residual signal from two successive scan lines. The size of the structural element of the filter is chosen adaptively based on the normalized second order moment of the local signal histogram. Results of implementing the algorithm on real wheel inspection data are presented.

Advisor: Lalita Udpa

Simon P. Huss

PhD, Summer 1998

Materials Science and Engineering

"Characterizing Spatial Variations of Composition and Porosity in Green Ceramics: Two Novel x-ray NDE Techniques"

Heterogeneities introduced during the initial stages of material formation largely control the reliability of ceramic materials. Spatial variations in porosity and composition introduced prior to or during consolidation can ultimately lead to cracks, warpage, or otherwise serious degradation in performance of the final part. A better understanding of how different processing variables affect the introduction and propagation of these heterogeneities is needed for further improvement in reliability. However, existing microstructural characterization techniques are inadequate to provide in-situ, spatially relevant data of the ceramic green body.

The development and application of two x-ray NDE techniques, quantitative energy dispersive radiography and density mapping through high resolution x-ray computed tomography, are described.

In a discrete SiC fiber reinforced mullite system, the energy dispersive technique demonstrated the ability of highly attractive particle networks to prevent fiber segregation. In monolithic ceramic centrifuge cakes, microfocus x-ray computed tomography was used to map three-dimensional variations in the green density as a function of ceramic compact compressibility and interparticle potential.

Advisors: Joe Gray and Chris Schilling

For more information about the Center for Nondestructive Evaluation, please contact:

R. Bruce Thompson, Director
Center for NDE
Iowa State University
515-294-8152 phone
515-294-7771 fax
cnde@cnde.iastate.edu

The Center for Nondestructive Evaluation is located in the Applied Sciences Complex, one mile northwest of Iowa State University's central campus.

Center for NDE
Applied Sciences Complex II
1915 Scholl Road
Ames, IA 50011-3042

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