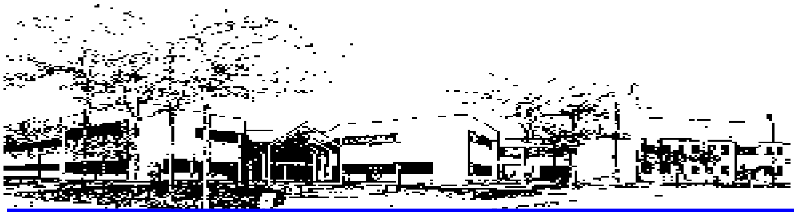
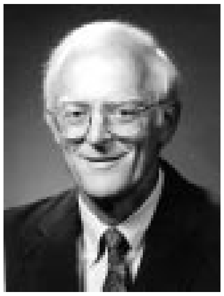


Center for
NDE NEWS
Volume 11 l Issue 3 l June 2000
Center for Nondestructive Evaluation - Iowa State University

The View from CNDE



R. Bruce Thompson

As we enter into the summer season, there is an accelerating level of activity at CNDE. Now that classes are over, our students and faculty members can devote their full attention to research, and many projects are moving forward at a rapid pace. In addition, as the Review of Progress in Quantitative Nondestructive Evaluation is being held in Ames for the first time, there are many other preparations. We are pleased to be able to show many of our friends and colleagues our local hospitality and look forward to seeing many of you here. An excellent program is shaping up as is described beginning on this page. As just one example, the plenary sessions on Imaging for NDE and Biomedicine should provide an excellent opportunity to assess the current status and interdisciplinary opportunities in this rapidly advancing area of technology.

In this issue of the CNDE newsletter, we are highlighting some new activities being developed at CNDE as we evolve in the context of national and international trends. Modeling has long been a thrust of the NDE research community, dating back to early work

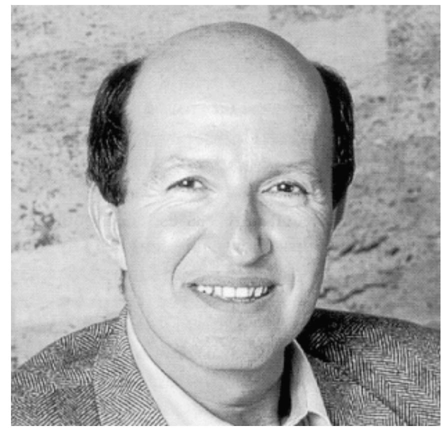
VIEW/continued on page 5

QNDE 2000 Comes “Home” to ISU

The 27th Annual Review of Progress in Quantitative Nondestructive Evaluation (QNDE) will be held in the Scheman Center at Iowa State University, Ames, Iowa, July 16-21, 2000. This is the first time ever—a millennium event—that this highly-regarded research and development conference has been held at the “home” of its host, the Iowa State University Center for NDE (CNDE). 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 an evening session that highlights new virtual reality applications with NDE.

This year’s keynote talks will feature reviews of cutting-edge advances in imaging with applications to both NDE and biomedical problems. These talks will be given at the conference opening on Monday morning, July 17, and should be interesting to people with a wide range of technical backgrounds.

The keynote talk will be given by Professor Mathias Fink, Labatorie Ondes et Acoustique, Ecole Supérieure de Physique et de Chimie Industrielles de la Ville de Paris, Université Denis Diderot. In his talk entitled “Time-Reversed Acoustics” he will describe both the fundamentals of time reversal in acoustics and experimental results illustrating applications including nondestructive testing of heterogeneous solids as well as medical imaging and therapy (destruction of kidney stones and brain therapy) and underwater acoustics (long-distance communication and mine detection). He has shown that the powerful time-reversal physical concept can produce remarkable improvements in difficult test problems.



Mathias Fink

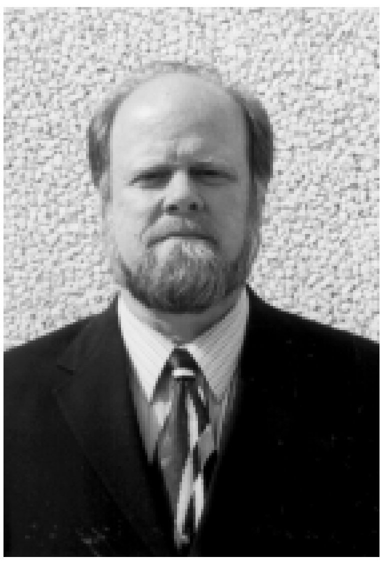
Two excellent speakers will follow the keynote talk. In the first of these Drs. Joe Gray of CNDE and Gerd-Rüdiger Tillack of the Federal Institute for Materials Research and Testing (BAM) in Berlin, will present a comprehensive

QNDE 2000/continued on page 2

INSIDE

QNDE 2000/continued from page 1

Gerd-RüdigerTillack



Joe Gray

CNDE News is published twice each year by the Center for Nondestructive Evaluation, a National Science Foundation Industry/University Research Center. CNDE is a member of the Institute for Physical Research and Technology at Iowa State University.

Editor: Linda Poore
Newsletter design: Jan Weedman
Thanks to the writers and information specialists at the Ames Laboratory/ IPRT Public Affairs Office for their assistance.

review of the explosion in x-ray based imaging methods that have taken place over the past 25 years. These include developments in x-ray hardware, data analysis, automated defect detection, models of the measurement process, simulation results, and others.

Michael W. Vannier

Professor Michael W. Vannier, Chair, Department of Radiology at the University of Iowa, will provide a wrap-up review of advances in imaging technologies that have improved patient care so much. His presentation will consist of two parts. First, he will give an overview of major imaging technologies including x-ray projection imaging, x-ray computed tomography (CT), magnetic resonance imaging (MRI) and magnetic resonance spectroscopy, single photon emission computed tomography (SPECT), positron emission tomography (PET), ultrasonics, electrical source imaging (ESI), electrical impedance tomography (EIT), magnetic source imaging (MSI), and medical optical imaging. In the second part, general issues that pertain to all areas of biomedical imaging in research and clinical practice will be delineated. This includes biomechanics, diffusion/ perfusion, computer-aided diagnosis and molecular imaging. The mathematical and physical basis of emerging medical imaging technology will be defined and illustrated with recent examples.

A special session in virtual reality has been organized for Wednesday evening, July 19, that should be of high technological interest to NDE researchers and users. This session will be held on campus at the Virtual Reality Applications Center (VRAC), a sister center of CNDE in the Institute for Physical Research and Technology (IPRT). This center is the home of some of the most advanced virtual reality equipment and research in the country and has some potentially powerful connections with NDE. Dr. Judy Vance, Professor of Mechanical Engineering at ISU and a member of VRAC, will provide the audience with an overview of the new C6 “cave” facility and discuss and demonstrate what can be done with it. It is expected that the session will include a brainstorming discussion of the virtual reality capabilities and how they might be used by the NDE community.

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).

The conference organizers invite both past friends of the conference as well as newcomers to attend. As noted earlier, this is the first time that the

QNDE 2000/continued on page 3

QNDE Speaker Biographies

Mathias Fink is a professor of physics at Paris 7 University (Denis Diderot) and at the Ecole Supérieure de Physique et de Chimie Industrielles de la Ville de Paris (ESPCI). He obtained from Paris University the PhD in solid state physics in 1970 and the doctorat es-Sciences degree on medical ultrasound imaging in 1978. Before moving to Paris, he served as a professor of acoustics at Strasbourg University. In 1990, Fink founded the laboratory Ondes et Acoustique at ESPCI, and in 1994 he was elected at the Institut Universitaire de France. His current research interests include ultrasonic imaging, ultrasonic therapy, nondestructive testing, underwater acoustics, active control of sound, analogies between optics and acoustics, wave coherence and time reversal in physics. He has developed different techniques in speckle reduction, wave focusing in inhomogeneous media, and in utrasonic laser generation.

Michael W. Vannier is a professor and chair at the Department of Radiology, University of Iowa School of Medicine in Iowa City, Iowa. He holds an MD from the University of Kentucky School of Medicine and has completed a diagnostic radiology residency at Mallinckrodt Institute of Radiology, Washington University School of Medicine, St. Louis, Missouri. His primary research interests are morphometry and anthropometry based on volumetric imaging modalities, especially computed tomography (CT), magnetic resonance (MR), and positron emission tomography/ single photon emission tomography (PET/SPECT). Dr. Vannier has served as editor-in-chief of the *IEEE Transactions on Medical Imaging*, and in 1994 was inducted into the U.S. Space Foundation Hall of Fame for work on digital medical imaging.

Gerd-Rüdiger Tillack is at the Federal Institute for Materials Research and Testing (BAM) in the NDE division concerned with radiation techniques. He received the doctorate degree in physics at the Institute for Theoretical Physics at the Technical University Dresden in 1992. At BAM he has worked on signal processing and statistically based evaluation of NDE methods, with current interests in simulation of NDE techniques (mainly radiation), and on the development of new 3-D reconstruction algorithms based on regularization and Bayesian techniques in case of restricted data sets. Tillack was awarded the 1999 Berthold prize by the German Society for NDT for his works on simulation. He is a member of the editorial board of the journal *Materials Testing* and is chair of the International Conference on Computer Methods and Inverse Problems in Nondestructive Testing and Diagnostics.

Joe Gray is a senior scientist and group leader at the Center for NDE at Iowa State University, Ames, Iowa, working in x-ray and neutron-based NDE methods. He received the PhD in physics at the University of Michigan in 1985. Gray's research areas of interest include the development of quantitative computer models for radiography, radioscopy, and high resolution computed tomography. Experimental activities include development of novel x-ray detectors, x-ray inspection of castings, heavy metal x-ray K-edge detectors for application to environmental cleanup, and development of image and signal processing techniques.

■

QNDE 2000/continued from page 2

conference will be held on the "home" campus. In addition to the normal conference activities, we encourage attendees and students from all universities, industries, and government groups to use the 2000 QNDE conference week as a time of reunion—a time to renew friendships and to promote professional partnerships. Conference planners will be pleased to offer suggestions of sites for special outings or off-site private receptions. They can arrange reserved seating for reunion groups at the Tuesday evening conference banquet. For information or assistance, contact Linda Poore qnde3@cnde.iastate.edu.

The Review of Progress in Quantitative Nondestructive Evaluation is sponsored by QNDE Programs and hosted by the Center for NDE, a member of the Institute for Physical Research and Technology at Iowa State University, in cooperation with the American Society for Nondestructive Testing, Ames Laboratory (USDOE), the Federal Aviation Administration, National Aeronautics and Space Administration-Langley Research Center, and the National Science Foundation Industry/ University Cooperative Research Centers. —*Donald O. Thompson*

■

CNDE Cluster Comes Alive

A dynamic “cluster” computer made of standard, low-cost personal computer components promises to keep CNDE on the leading edge of high-performance computing for years to come. This parallel processing computer, being built in an old minicomputer room at CNDE, brings the power of some 30 individual machines to bear on a single problem by dividing the work and processing the various sections simultaneously. The result is a machine that provides computing speeds approaching, or even exceeding, a more conventional system costing ten times as much.

“This will be an important resource for the people here,” says CNDE scientist Feyzi Inanc, one of the lead instigators of the project, along with group leader Joe Gray. The cluster will be used to run various programs and simulations related to nondestructive evaluation by CNDE and its partners. It was built with funding from Iowa State University, the Federal Aviation Administration and Northwestern University. Inanc and Gray played key roles in obtaining funding and building the machine. CNDE system administrator Dave Orman and student assistant Jason White helped design and build the machine and are responsible for maintaining and upgrading it.

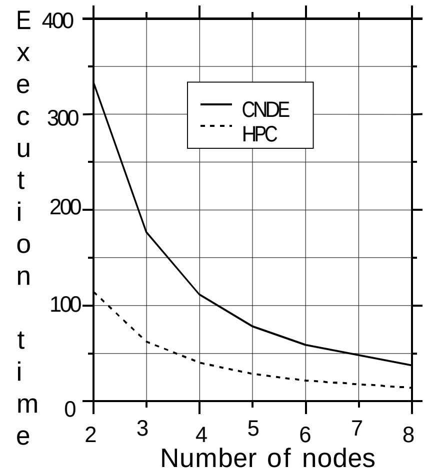
The Cluster Advantage

Inanc and Orman explain that the team made “bang for the buck” its overriding goal in building the as-yet-unnamed machine. “The whole point of clusters is to build a high-performance machine out of low-cost, off-the-shelf hardware,” Orman says. What’s more, the group minimized other costs. “Ninety-nine percent of the money is going into hardware,” notes Orman.

In addition to high speed at a low cost, the CNDE cluster offers other benefits over more traditional high-performance computers. “The advantage of a cluster is that it is ‘forward compatible,’” says Inanc. As such, the CNDE cluster can grow and change as applications dictate, meaning that the system won’t become obsolete like single-processor high-performance machines. Inanc notes that additional computers, or nodes, can be added as needed. Existing nodes also can be upgraded with more memory or faster processors as they become available and affordable.

CNDE tapped resources close to home to help build its cluster. ISU is home to at least eight other clusters. Many of these systems were designed and built by the Scalable Computing Laboratory(SCL) of the Ames Laboratory. SCL researchers were pioneers in cluster computing and have built several of their own clusters. The lab also helps other researchers build clusters and modify their software to run on them. Inanc and Orman discussed their needs with SCL researchers before designing the CNDE cluster. Inanc, with help from ISU’s Dave Turner and Bogdan Vasilu, was able to create and debug a parallel version of his x-ray simulation software, before the CNDE cluster was even built, by accessing a similar cluster computer called ALICE located at SCL.

Already, the center has taken advantage of the dynamic nature of its cluster. By starting out with ten nodes, Inanc and Orman were able to test the system and fine-tune its operation. This system can run Inanc’s x-ray simulation code at speeds approaching that of a more traditional parallel processing system costing much more (see figure).



Execution times versus number of nodes for x-ray simulation code on the ISU HPC Group Origin2000 and the CNDE cluster show that performance of the CNDE cluster approaches that of the Origin2000, a more expensive, shared-memory machine.

Orman took into consideration the computational needs of software that researchers from Northwestern University plan to run on the machine in order to have a better idea of how to configure the next group of nodes, which have been ordered.

Inanc’s work can greatly benefit from an ultrafast computer; he hopes to ultimately take his x-ray simulation software into the biomedical world. In image-guided surgery, for instance, surgeons need near real-time simulations that may only be possible through the power provided by a cluster computer.

Even though the CNDE cluster will soon encompass more than 30 processors, Inanc believes the system could benefit from more nodes. He’s making an unusual proposition to industrial and research partners: donate a small number (perhaps five or six) PCs or their equivalent cost, and CNDE will add them as nodes to the cluster. In turn, the donor can access an even more powerful CNDE cluster.

CLUSTER/continued on page 5

CLUSTER/continued from page 4

Running a Beowulf

The CNDE cluster is a “Beowulf” machine, a class of parallel machines whose name derives from the original system that was constructed in 1994 for NASA. These systems are typically custom-built rather than purchased. Such clusters are quickly becoming the supercomputer of the 21st century, thanks to their combination of low cost and high performance as well as their ability to run a broad range of software.

As a Beowulf machine, the CNDE cluster takes advantage of standards wherever possible to keep costs down and to make the cluster as versatile as possible. Its individual nodes house 500 MHz Celeron processors with 256 megabytes of RAM; the nodes are connected via a standard “fast ethernet” network operating at 100 megabits/sec. The CNDE cluster uses a single, shared hard disk rather than a separate hard disk for each node. Such hardware can be easily replaced and upgraded from a variety of sources, says Orman.

The system runs a version of the Linux operating system, which has become the standard for cluster computers and is fast gaining popularity in the general computer market as well. Orman says that the team modified Linux to suit the needs of the machine. “By doing it ourselves, we get exactly what we want and know how it works,” he says. The machine offers a Fortran compiler for compatibility and speed; standard C and C++ compilers are also available. Both parallel virtual machine-based (PVM) and message passing interface (MPI) standard-based implementations (MPICH and LAM) can run on the cluster.

Orman also worked to make maintenance and upgrading of the system as simple as possible. Additional nodes can simply be plugged into the network. Proof that this approach worked: the first incarnation of the system took only about two weeks to build.

–Feyzi Inanc

VIEW/continued from page 1

sponsored by the Air Force and Defense Advanced Research Programs Agency as a part of the Interdisciplinary Program for Quantitative Nondestructive Evaluation. Once a primarily academic activity producing physical understanding and documented in archival papers, results are now incorporated in simulators that are being directly used by industry in the design and interpretation of nondestructive measurements. On page 4, Feyzi Inanc discusses a step in this evolution that is currently under way at CNDE, the use of clusters of PCs to achieve dramatically enhanced computational power at a very modest cost, thereby making increasingly sophisticated models accessible to the NDE researcher and practitioner.

The need to couple research and undergraduate teaching is becoming increasingly recognized as an important step in improving the quality of education. On page 7, a recently established program in Vertically Integrated Design is described. Under funding of the NSF’s Combined Research and Curriculum Development Program, NDE and its role in life-cycle engineering is being used as the basis for broadening the education of the materials science and engineering students. An important ingredient is the use of simulators as teaching tools. The NDE minor offered by the College of Engineering at Iowa State University, as described on page 6, provides a mechanism to further enhance this coupling between research and undergraduate education.

Many NDE techniques were developed in response to needs to ensure the integrity of structural components. However, from a broader perspective, these are non-invasive measurement techniques that can find applications in many other areas. An example in the food processing area is discussed in this issue. On page 8, the application of low frequency acoustic techniques to determine the “doneness” of bread is described. This represents one of many opportunities to apply the expertise of the NDE community to new sets of important problems.

CNDE takes pride in accomplishments of its staff and page 6 announces two recent awards that have been received. One goes to Professor Frank Rizzo, a senior faculty member for his contributions to the boundary element technique that is now finding wide spread application to NDE and the other to a graduate student, Leon Pickett, who is just beginning his career. Additional information about upcoming graduates of CNDE may be found on page 9.

We look forward to seeing many of you in July. If your schedule allows you to stay for Friday afternoon after the conclusion of the Review of Progress in Quantitative Nondestructive Evaluation, we would be pleased to have you visit us at CNDE. Until then, best wishes in your work and other summer plans.

The NDE Engineering Minor at ISU

Do you know someone who would like an engineering bachelor's degree with NDE engineering written all over it? In that case, have them contact Iowa State University, the only school in the country to offer an engineering minor in nondestructive evaluation at the bachelor's level.

The NDE minor had its origins in some important workshops in the 1980s, including sessions held at the ASME's Pressure Vessel and Piping Conference and the Review of Progress in Quantitative Nondestructive Evaluation. It was concluded that industry needs staff with a special educational background to implement emerging quantitative NDE techniques. However, the consensus was that this "need" would be best filled by individuals with a degree in a traditional discipline but with specialized expertise in NDE.

The NDE minor began as a series of very popular courses offered by staff of the Center for NDE and faculty members in the College of Engineering. CNDE staff and the faculty of both aerospace engineering and engineering mechanics and materials science and engineering organized to petition the ISU College of Engineering and ultimately the Board of Regents to establish a new minor in NDE. The ball got rolling with a positive decision by the engineering faculty in the spring of 1994, and in May of that year the ISU Faculty Senate unanimously approved the new minor.

The ISU NDE minor can be elected in conjunction with any BS degree program offered in the College of Engineering, although majors in mechanical engineering, aerospace engineering, engineering science, materials engineering, and civil engineering seem to fit best. The NDE minor requires that the student take several additional courses from an approved list. There are three categories of courses for the NDE minor: required courses, NDE specific courses, and supporting courses. The required course is a junior-level MSE survey course that includes a lab. Two NDE–specific courses are needed. The most popular are independent study under a CNDE researcher, and the graduate NDE course taught in AEEM. The supporting courses comprise a long list of advanced undergraduate courses in topics related to NDE.

Of the courses for the NDE minor, a student can apply six of the approximately 16 credit hours toward other requirements of his or her degree. That leaves about ten credit hours that must be taken in addition to other curriculum. For this extra effort the student gets the designation "NDE Engineering Minor" engraved on the degree, and the same designation becomes a part of the student's permanent record and transcript.

Plus, did we mention that ISU is the only school in the nation to offer this recognition for the study of NDE? For further information, please contact the CNDE office at 515-294-8152 or the AEEM department at 515-294-6241.

So, if you know someone who wants "NDE" written all over their bachelor's degree, please point them toward Iowa State. More detailed information can be found on the web page at http://www.public.iastate.edu/~chimenti/NDE-Minor/Minor-descrip1099.pdf. — *Dale E. Chimenti*

Honors and Awards

The American Society of Mechanical Engineers recently elected Frank Rizzo, professor of aerospace engineering and engineering mechanics, a fellow to the international professional society for his work on a calculation method known as the Boundary Element Method.
The method is based on mathematics that were developed in the 1800s for a different purpose, but more than 30 years ago Rizzo saw that the emerging digital computer could breathe new life into the old math. The boundary element method has greatly increased the ease, speed and accuracy of computation for many complicated engineering problems as compared to volume-based methods. Now, with modern computers and point-and-click software, one can do difficult analysis and design with little background in technical computation.

ISU graduate student Leon Pickett received two major fellowships this spring that will help fund his pursuit of a PhD in engineering mechanics. Pickett has been acquainting himself with CNDE's research on NDE for composites, mostly using ultrasonic techniques, and is developing a thesis plan with Dave Hsu and Vinay Dayal. In February, he was awarded a fellowship from the National Consortium for Graduate Degrees for Minorities in Engineering and Science, Inc. (GEM)—the first ISU doctoral candidate to receive the award. In April, ISU awarded him with a George Washington Carver Doctoral Fellowship. The two fellowships will pay Pickett's tuition and an annual stipend for three years. As part of the GEM fellowship, he is spending three months at Ford Motor Company in Detroit as a product development engineer.

CNDE a Part of Grant to Enhance Engineering Curriculum

As part of a $439,000 grant from the National Science Foundation, the Center for Nondestructive Evaluation will provide industrially relevant research opportunities for materials science and engineering students. The projects will broaden students' views of materials design by using computer simulations to illustrate the entire life cycle of components, including the important role of nondestructive evaluation in ensuring reliability.

The award of the grant is in response to changes in manufacturing industries that require young engineers to possess a diverse range of skills, including a well-rounded understanding of the interplay between materials properties, design, manufacturing, inspection, degradation and failure. Currently, Iowa State University engineering students take a capstone senior design course; however, industry needs have led faculty to conclude that the conventional senior design approach is no longer sufficient to meet the demands of high technology industries. "The need for more hands-on experience in our graduates may best be met by providing research opportunities throughout students' undergraduate careers," said David Jiles, an ISU materials science and engineering professor, Ames Laboratory and CNDE scientist and lead investigator on the grant.

The goal of the NSF-funded project is to incorporate engineering design experience into the curriculum through the concept of "vertically integrated design." The idea was first proposed by the ISU materials science and engineering department during reorganization of its undergraduate curriculum and was continued in the proposal for the NSF grant. The proposed curriculum changes include three courses, a one-credit sophomore laboratory course and two-credit lecture and laboratory courses in the junior and senior years. Students will begin as apprentices in their sophomore years, working on industrially driven projects at CNDE with senior and graduate engineering students. Over their junior and senior years, they will gradually progress to become team leaders. A critical part of the curriculum will be the introduction of tools and equipment to study the life cycle of manufacturing elements.

CNDE is an ideal location for students to gain this experience. "CNDE provides an ideal vehicle for developing the concept of vertically integrated design together with strong industrial collaboration in setting research goals. The center has also developed advanced computer simulation software in a number of areas, which can be used to improve materials selection, design and inspectability in manufacturing," said Jiles.

CNDE's 21-member Industrial Advisory Board of corporate sponsors and the nine members of the materials science and engineering's Industrial Advisory Council will strengthen the program's ties to industry by providing guidance in curriculum development and identification of industrially relevant problems for research. Currently, project offerings include design of optimized magnet arrays for magnetocaloric refrigeration systems, x-ray energy dispersive material characterization and analysis of time-domain eddy-current signals. Engineering faculty and CNDE scientists, often in collaboration with industry representatives, will lead these projects. The interaction with industry is also expected to help students build relationships, thereby gaining a competitive edge in obtaining internships and future employment.

Reprinted with permission from the IPRT Link newsletter

Engineering student Zach Nielsen examines corrosion on an airplane wing in an ultrasonic immersion tank at the Center for Nondestructive Evaluation. Materials science and engineering students will engage in similar advanced computer and life-cycle testing projects through the new Combined Research and Curriculum Development Program.

ISU Bread Research Isn't "Half-baked"

Iowa State University researchers Dale Chimenti and Loren Faeth say they are cooking up something special in their laboratory. They add that they want their research to rise to the occasion.

That's a bread joke. The two can be forgiven for that, because they are, after all, researching the art of bread baking.

What Chimenti and Faeth are working on in their lab could save the $27 billion-a-year bread industry in the United States a lot of money and improve the quality of bread.

"Right now, an amazing amount of bread goes to the dumpster and to the thrift store, and that's lost profit," Faeth said. "This is an industry with a small profit margin. If you can improve the margin even a little, that's a big deal. By my assessment, the best way to do that is to cut back on the bread that ends up as waste."

Faeth was a researcher at CNDE and a PhD candidate at ISU working to complete his degree in industrial education and technology. He had also worked in the bread industry for ten years. He first thought about the problem of better monitoring bread doneness when he was working in industry. Then, while looking for a PhD project to complete his thesis Faeth contacted Chimenti, a professor of aerospace engineering and engineering mechanics and a senior scientist at CNDE, about the bread problem. The two began researching it about three years ago, and Faeth used that research as his PhD thesis, which he received in May 1998.

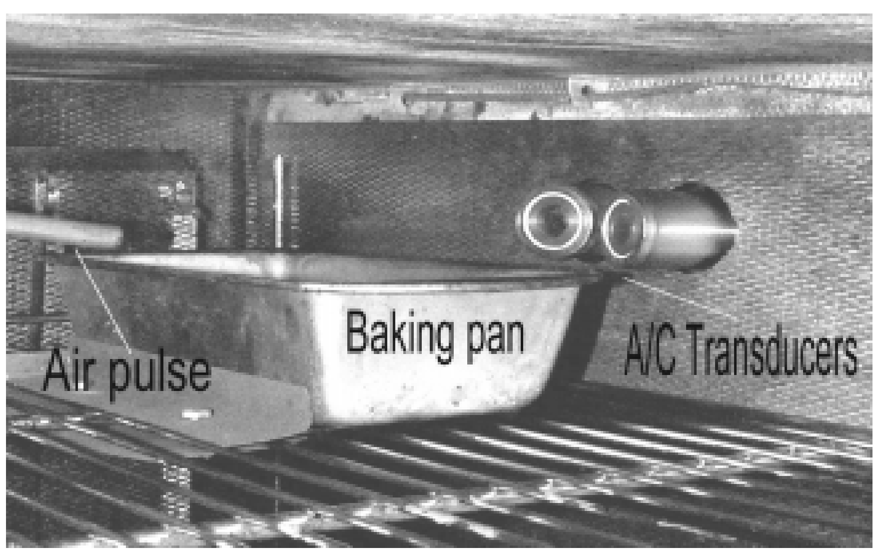
Too often, the only measures used to determine if bread is ready are time and temperature, and these can be influenced by varying factors, Chimenti said. But experienced bakers use a well-tested method to determine if bread is done; the craft method consists of thumping on the loaf with a knuckle and listening to see if it has the right sound and feel.

"Commercial bakeries don't do as good of a job determining when their bread is done as we think they might," Chimenti said. "Our idea is to provide an engineering means to mimic a craft method used by expert bakers and to apply this method while the bread is baking in a commercial oven. We think we have hit upon a method that looks promising."

The system consists of two components connected by the response of the baking loaf. The first is a measured pulse of hot air provided by a storage volume at a regulated pressure. A valve opens and permits air at a few pounds gauge pressure to impact on the crown, or upper part, of the baking loaf. Simultaneously, a pair of air-coupled transducers operating at 100 kHz in a pitch-catch mode "stare" at the loaf from the opposite side. As the stress wave caused by the air pulse propagates through the loaf and impinges on the opposite surface, it causes small transient motions of the loaf. These motions can be detected with a system that exploits the inherently high spatial resolution of ultrasonics.

The researchers constructed their detection system using the sending transducer to insonify the loaf with a short toneburst (at 100 kHz) that is repeated as quickly as the travel time delay from sender to receiver will allow. Then, the received signal is detected by a "boxar" amplifier. Using a very narrow detection aperture, whose time position is anchored to the sending toneburst, permits the amplifier to perform like an acoustic interferometer — but with excellent time resolution. In fact, the system, built only with off-the-shelf components, has a demonstrated spatial resolution of about 30 micron at a stand-off distance of two inches and can resolve these small motions of the loaf down to time frames as short as about two millisecond. These stringent performance requirements enable high-resolution sensing of internal changes in dough products during the baking process to ensure doneness. In only a few seconds, the system performs the thumping function and collects the resulting loaf recoil motion information to determine the internal elasticity of the bread. The system has been tested on more than 100 loaves of bread and shows promise, Chimenti said.

BREAD/continued on page 10



CNDE Celebrates With ISU Graduates

CNDE, in cooperation with several academic colleges at ISU, 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, follow.

Harpreet Wasan
MS, Spring 2000 AEEM
"Influence of Microstructure on Ultrasonic Detection of Flaws in Aircraft Engine Alloys"

Two studies are conducted pertaining to ultrasonic inspections of jet aircraft engine materials. The first study involves a nickel-based engine alloy having metal grains which are small compared to the sonic wavelength. The object is to measure basic ultrasonic properties at several locations in a turbine disk, for subsequent use in Probability-of-Detection (POD) calculations. The measured quantities are the speed of sound, attenuation and backscattered-grain noise capacity (FOM). It is found that in a small region of uniform microstructure (without unrecrystalized grains), these properties are independent of direction. Observed variations of ultrasonic properties within the disk are then traced to variation of the average grain size. Grain noise capacities, predicted from measured grain size distributions, are shown to be in good agreement with experiment. Finally, a demonstration is performed showing how the basic property measurements of the nickel-based alloy can be used in the estimation of POD curves for hypothetical internal defects in an engine disk. The second study involves engine titanium alloys in which the large-scale component of the microstructure (i.e., the macrostructure) is larger than the ultrasonic wavelength. In such alloys, ultrasonic echoes from identical defects in a metal component will vary due to the influence of the local microstructure in which each defect is embedded. Two effects are responsible: (1) the scattering of sound at nearby crystallite boundaries results in "grain noise" which is superimposed on the defect echo; and (2) the intervening microstructure modulates or distorts the sonic field that is incident on the defect, thus modifying its echo. Both effects can be significant in engine titanium alloys, and both influence inspection reliability. In this work, a series of experiments is performed to investigate signal fluctuations primarily arising from the second effect. Arrays of nominally identical #1 flat-bottomed holes (FBHs) in Ti-17 and Ti 6-4 specimens are scanned using a 10-MHz, broadband, focused transducer. The peak echo amplitude of each FBH in the array is measured, and the ratio of the standard deviation of the peak amplitudes to their mean serves as a dimensionless measure of the fluctuation level. Similar measurements are performed on a fine-grained nickel specimen that serves as a reference. The fluctuation level and the apparent average ultrasonic attenuation are measured as functions of alloy, propagation direction, frequency, and inspection water path (i.e., degree of beam focusing). In addition, beam distortions are studied by analyzing the sizes and shapes of the C-scan images of the FBHs. The fluctuation level and other effects of beam distortion are found to be most severe when the sound beam propagates parallel to the macrograin elongation direction. It is shown that the fluctuation level can depend strongly on the location of the defects relative to the focal zone of the sonic beam. When the defects are located in the focal zone, the fluctuation level is reduced, but the apparent mean ultrasonic attenuation is largest.

Advisors: Bruce Thompson and Vinay Dayal

Xiaoming Yu
MS, Summer 2000 EE
"Ultrasonic NDE signal classification with Wiener filtering deconvolution"

This thesis presents a method for discriminating different types of ultrasonic flaws signals collected from steam generator using pulse-echo reflection techniques. The proposed method uses various signal processing, image processing techniques to extract features from ultrasonic signals. Then several pattern recognition techniques are used to get the optimum classification results. The training and testing with these features shows that a better performance than in previous efforts is achieved. In the ultrasonic area, it is often desired to deconvolve the impulse of transducers from the A-scans to recover the impulse response (IR) from real flaws. The duration of the deconvolved IR should be shorter than what we observe in A-scans. The longer duration in the A-scan often hides some information such as the exact location of flaw, which might make classification more difficult. To overcome this problem, Wiener filtering deconvolution technique is introduced in this project to get better resolution in time domain and get more possible features other than those from the original signals.

Advisor: John Basart

We wish to acknowledge with thanks the following agencies and industrial sponsors who have helped to develop the Center for NDE through their financial support and technical interests. We hope this newsletter contributes to achieving a common goal - the continued development of both technology and people for NDE as an engineering discipline.

Aluminum Company of America
The Boeing Company
Caterpillar, Inc.
Eaton Corporation
Electricité de France
Federal Aviation Administration
General Electric Company
Herzog Services, Inc.
Honeywell Engines and Systems
Howmet Corporation
Knolls Atomic Power Laboratory
National Aeronautics and Space Administration
National Science Foundation
Pratt & Whitney
Rolls-Royce Allison
Samsung Advanced Institute of Technology
Siemens Westinghouse Power Corporation
Sperry Rail Service
United Technology Research Center
U.S. Department of Energy
Westinghouse Electric Corporation

BREAD/continued from page 8

"The advantages are that it's completely noncontact and can be used inside an oven while bread is baking," he said.

A patent is pending on the technology, and the two are attracting interest from commercial-oven manufacturers and bread companies.

Initial funding for the project came from ISU's Institute for Physical Research and Technology, and additional funding came from ISU's Center for Advanced Technology Development.

"We think we can improve on this and help the industry be more precise," Faeth said. But to do that, the researchers will need more dough. —*Dale Chimenti*

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

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

R. Bruce Thompson, Director
Center for NDE
Iowa State University
515-294-8152
FAX: 515-294-7771
cnde@cnde.iastate.edu
http://www.cnde.iastate.edu