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Dr. Fredrick (Bud) Brust

Senior Research Leader
Computational Modeling and Engineering Mechanics

Education

B.S., Civil Engineering, University of Dayton
M.S., Structural Engineering, Purdue University
Ph.D., Computational Mechanics, Georgia Institute of Technology
Sabbatical - Computational Modeling Center, Georgia Institute of Technology, 1995

Qualifications and General Experience

Dr. Brust joined Engineering Mechanics Corporation of Columbus in October, 2007, after a 27 year career at Battelle where he was one of 10 institute wide Senior Research Leaders, the highest technical position at Battelle. Dr. Brust has extensive experience directing and managing large engineering research and development programs in the Civil, Nuclear, Mechanical, and Aerospace Engineering disciplines. Brust's main area of specialization is the development of computational solutions to engineering problems, using techniques such as the finite element method. He is a specialist in all aspects of fracture mechanics. Some of the general experience is listed below.

- **Finite Element Modeling.** Twenty five years experience in linear and nonlinear finite element analysis for structures and heat transfer. This experience includes writing specialty nonlinear codes, writing subroutines for a variety of commercial codes, a commercially available finite element alternating code (FRAC@ALT^{TM}), and a commercially available weld modeling code (VFT^{TM}).
- **Fracture and Fatigue.** Twenty five years experience in fracture analysis. This includes development of linear and nonlinear fracture codes, development of fracture control methods for structures, fatigue control, and corrosion crack growth control. This experience has been applied to a variety of industries including aerospace, nuclear, civil, naval, and mechanical equipment industries. Has extensive experience in failure investigations.
- **High Temperature Structures and Damage.** Led the development of state-of-the-art computational modeling tools to permit design and life assessment of micro-tech devices in very high temperature chemical processes. This includes the development of a micro-tech fabrication process model. Issues include high temperature fatigue, corrosion, creep, and fracture control. In addition, recent work has focused on nano-scale studies of void nucleation and growth due to diffusion and flux transport along grain boundaries.
- **Composite Structural Analysis and Damage Control.** Directed the analysis efforts on a number of structural composite programs. This included a probabilistic risk assessment (PRA) of the Mars Earth Entry Vehicle which is made of high performance composites, including Carbon-Carbon, Graphite-Polyamide, and metallic components. He is also a consultant to the Navy regarding delamination control of components of the trident missile system, most recently regarding delamination issues regarding the nose fairing.

- **Software Systems.** Led the technical development of the Virtual Fabrication Technology (VFT^{TM}) software, which is used for modeling metallic fabrication including the cutting and welding. VFT is implemented throughout the worldwide business units of a large heavy equipment manufacturer to manage residual stresses and distortions in welded fabrications. VFTTM is now commercially available and is used in the ship building industry as well as by The Welding Institute (TWI) and Battelle. Also developed the FRAC@ALT^{TM} software, which is based on the finite element alternating method. FRAC@ALT is now commercially available and used in the nuclear and naval areas at present.

Recent Detailed Experience

- **NASA Super Problem Resolution Team.** He is contracted to be part of NASA's National Engineering and Safety Center (NESC) to be part of the Super Problem Resolution Team (SPRT) for structures and to provide consultation and independent review of structures issues. Brust reviews structures and fracture related issues for the space shuttle, space station, the ARES shuttle replacement, and other structures related issues for NASA Langley. Issues studied recently include the external tank insulation impact damage on the shuttle, LOX tank cryogenic fracture problems, space shuttle main engine liner cracking problem, space station module leak before break fracture concern, composite wrapped pressure vessels and weld fracture issues, among many others. The liquid oxygen cryogenic fracture issue was in regard to the Kennedy Space Flight Center liquid and oxygen tanks that were a concern several years ago.
- **High Temperature Design Methodology.** Developing state-of-the-art computational modeling tools to design micro-tech devices for use in very high temperature chemical processes. Micro-tech based catalytic reactions, which require significant mass transport, are an emerging field. The associated high temperatures required are an additional challenge. This includes the development of a micro-tech fabrication process model, which will likely lead to additional intellectual property. The work is in support of a large venture between Battelle and three oil companies and has resulted in a new company.
- **Earth Entry Vehicle (EEV) Composite Damage and PRA Assessment.** Led the deterministic efforts on this program that was concerned with assessing the damage development in the future Mars EEV Lander. The EEV is made of a series of high performance composites, including Carbon-Carbon, Graphite-Polyamide, and metallic components. A probabilistic risk assessment (PRA) of the risk of failure was the ultimate goal of this program. Numerous, large scale composite damage based nonlinear finite element analyses were required.
- **Program Management of Fabrication and Weld Model Development Software.** Led a multi-million dollar program for a heavy industrial fabricator as part of a NIST ATP program. The program purpose is to develop fabrication and weld-modeling software for complex and large structures to produce a computer based 'virtual' weld modeling laboratory. The software is used to control distortions and residual stresses caused by the welding process, and thereby greatly reduce manufacturing costs. Duties included leading numerous staff (both from Battelle and the manufacturer) as part of a Battelle led 'virtual team'. Program management duties included coordinating the efforts between Battelle and the multiple state located Caterpillar manufacturers.
- **Nano-Scale High Temperature Analysis and Damage**. Have been leading a basic grant program over the last 10 years from Department of Energy – Office of Basic Engineering Sciences (DOE OBES) to study the high temperature damage development and crack growth process. Recent attention has focused on nano-scale studies of void nucleation and growth due to diffusion and flux transport along grain boundaries. This research has applications to components operating at high temperatures in power plants, jet engines, and space shuttles. This work has resulted in numerous fundamental and applications papers in international journals.

- **Virtual Fabrication Technology (VFT™ Software).** Leading the Distribution and sales of software for controlling fabrication processes (distortions and residual stresses). Have just entered into a negotiated agreement with a European Agency for European and Asian sales.
- **Trident Nose Fairing Composites.** Consultant to the Navy on delamination control of the nose fairing for the Lockheed Martin Missile and Space (LMMS) trident missile system. Overseeing the LMMS analysis of potential delamination growth and failure of nose fairing. The nose fairing is made of an 18-layer system of composites.
- **Power Valve Assessment.** Developed computational modeling approach for industrial power plant high temperature and pressure valve manufacturer. Manufacturer is now using the tools to design valves to achieve higher temperatures and reduce manufacturing costs.
- **Ship Fabrication Distortion Control.** Performing weld distortion control analyses for several large Naval shipyards and for the US Navy. The analyses, which are finite element computational models, are used to optimize weld procedures to control weld induced distortions and residual stresses. Significant cost savings are being realized by reducing the need for re-work.
- **Probabilistic Damage Tolerance Assessment for Aging Aircraft.** Led the deterministic methods development and applications of fatigue and fracture mechanics technology in a program to investigate the integrity of aging aircraft for the FAA and Air Force. A new ongoing effort, for the FAA only, continues to further improve the computational tools. This large effort involved leading the technical developments between a number of Battelle and subcontractor staff members. This work involved the development and enhancement of special computational methods to permit cost-effective assessment of the effects of multiple site and multiple element damage on commercial and military aircraft. The tools are state-of-the-art life prediction and fracture analysis finite element based computer tools.
- **Bimetallic Weld Crack Growth and Fracture.** Performing corrosion and fracture analyses for a hot leg fracture problem in a nuclear power plant. The power plant experienced serious unexpected cracking in the large hot leg pipe that is welded to the vessel. It involves a Ferritic steel vessel nozzle, Inconel weld metal, and safe end pipe of 304 SS. The work is being performed for the US NRC.
- **Structural Damage Assessment of Structural Fabrication.** Part of a program that investigated the damage development and fracture response of buildings that were affected by the Northridge earthquake (SAC program). The complications induced by the dynamic nature of the earthquake loading on the beam column connections and the corresponding brittle fracture responses were investigated.
- **Elastic-Plastic Fracture Estimation Handbook for Straight and Curved Cylinders.** Led the development of a J-integral based fracture analysis handbook based estimation procedure for straight and curved cylindrical vessels. Required extensive fracture based finite element solutions along with analytical estimation schemes.
- **Model Development Analytical Tools For Thin Sheet Fabrication.** Leading a program to develop numerical process models for an automotive frame manufacturer. The methods developed include handling complications induced by the nature of the 'thin' sheet fabrication required and handling the potential buckling issues inherent in welding of thin sheet.
- **Process Model Development.** Dr. Brust has been involved with the development of computational models that simulate many industrial processes. These developments include processing of thin polymer films to a rigid and geometrically complicated substrate, combination glass/metal electrical insulators, high temperature composites processing, and thermal barrier coatings methods, among many others. Such models are used to optimize the fabrication process and reduce costly prototype requirements.
- **Fracture Analysis Nuclear Reactor Power Plants**. Developed fracture assessment methodologies in a large program aimed at assessing flawed nuclear components such as vessels and piping using

nonlinear fracture mechanics techniques. This work included performing numerous 2- and 3-D nonlinear finite-element analyses along with utilizing and developing simplified estimation techniques and implementation of these techniques into a user friendly computer code. The development of a practical J-Integral based plastic fracture mechanics assessment methodology resulted that is used extensively today in the nuclear industry.

- **Engine Design and Life Assessment Procedure**. Evaluated the design and life assessment specifications documents for a European (NATO Country) Air Force. This assessment involved a detailed study of the analysis procedures used to design gas turbine engines to achieve a desired life and the implementation into a series of design life documents. The work involved providing suggestions and modifications to improve the effectiveness and adequacy of the procedures.
- **Engine Recuperator (Heat Exchanger)**. Investigation of failure causes and solution of a failure problem in a gas turbine engine recuperator. The assessment and solutions required extensive thermo-elastic-plastic-creep finite-element analysis with many nonlinear effects (contact, friction, orthotropic properties, etc.) The heat exchanger consists of a series of stacked plates requiring judicious use of many of the non-linear analysis features of ABAQUS to render the analysis financially tractable. The analyses were developed to perform a failure analysis and to recommend design modifications to increase component life.
- **Composites Failure and Fracture.** *Metal Matrix Composite Damage*. Analyses of metal matrix composites in order to predict the damage accumulation and failure modes were made using micro-mechanics methods. A methodology was developed to predict damage modes that compared very well with experimental data. Predictive fracture mechanics and damage theories for MMC's were developed and extensively applied. *Life Prediction of Ceramic Matrix Composites*. Life prediction methods for ceramic matrix composites for high-temperature application were developed. This requires close cooperation between experimental and analytical work. Current emphasis is on a hybrid (dual fiber) CMC system. This work was performed for NASA and several of the engine manufacturers.

Professional Affiliation and Publications

- Brust has more than 220 publications consisting of more than 65 rigorously refereed international journal papers, more than 65 rigorously reviewed conference proceedings publications and book articles, more than 95 moderately reviewed articles and presentations, and a number of technical reports. A publication list is available upon request. Brust also has also provided numerous keynote lectures at conferences in the US and overseas, has edited a number of technical books, and written book chapters.

- He is an active member of the American Society of Mechanical Engineers (Materials and Fabrication Committee and Applied Mechanics Division), American Welding Society, American Society for Testing and Materials (Committee E-24/E-08 (Fracture and Fatigue) and Committee D-10 (Composites), and the American Society for Composites. In addition, he is a founding member of the International Society for Computational Engineering and Sciences (ISCES). He also serves on several editorial boards, including editorial board of International Journal *Computer Modeling in Engineering & Sciences*, 2000 to present and the editorial advisory board of International Journal *Computer Modeling and Simulation in Engineering*, 1996 to 2000.