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Experimental Benchmarking of Fire Modeling Simulations

Final Report

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Award Duration: 9/98 – 9/02

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Summary

A series of large-scale fire tests were performed at Sandia National Laboratories to simulate a nuclear waste transport package under severe accident conditions (Figure 1). The test data were used to adjust the Container Analysis Fire Environment (CAFE) computer code (Figure 2). CAFE is a computational fluid dynamics fire model that accurately calculates the heat transfer from a large fire to a massive engulfed transport package. CAFE will be used in transport package design studies and risk analyses.

To date, this project has received $142,708 of co-funding and continuation funding from four different agencies. This support is roughly equal to the $149,784 received from EPSCoR. This funding supported 6 master's degree candidates and four undergraduate students. This work has been reported in eight refereed publications (two in archival journals and six in reviewed conference proceedings) and five invited lectures. Summaries of the co-funding, student support, and publications are given below.

Co-Funding and Continuation Funding

State of Nevada, Agency for Nuclear Projects, "HLW Highway Transportation Safety Issues: Shipping Cask Performance in Severe Accident Fire Environments," #00/01.0006, 5/00 to 6/00, PI: M. Greiner, $52,000.

State of Nevada, Agency for Nuclear Projects, "Severe Fires Under High Wind Conditions: Potential Implications for Spent Nuclear Fuel Transportation," 5/01 to 9/01, PI: M. Greiner, $14,430.

Sandia National Laboratories, "Effect of Package Placement on Fire Response," 1/02 to 9/02, PI: M. Greiner, $49,990.

Sandia National Laboratories, "Package Performance Study Peer Review Panel," 1/02 to 12/02, PI: M. Greiner, $5,288.

Nevada Applied Research Initiative, "Benchmarking and Use of the Container Analysis Fire Environment (CAFE) Computer Code," 1/02 to 7/03, PI: M. Greiner, $16,000.

Hoefer Foundation, "Benchmarking and Use of the Container Analysis Fire Environment (CAFE) Computer Code," 1/02 to 7/03, PI: M. Greiner, $5,000.

Students Supported

Masters Degree Candidates

M. Alex Kramer (completed 12/01)
H. Ju (completed 8/01)
N. Are (anticipated completion 5/03)
S Umpapalli
V. Govindaraju
H.S. Sunkara

Bachelor Degree Students

M. A. Kramer (completed 5/99)
K. Davis (anticipated completion 5/02)
K. Parker (anticipated completion 5/02)
A. Broch (anticipated completion 5/02)

Publications

Refereed Journals

Ju, H., Greiner, M., and Suo-Anttila, A., "Computer Simulations of a Generic Truck Cask in a Regulatory Fire Using the Container Analysis Fire Environment (CAFE) Code," *Int. Journal of Radioactive Materials Transport*, Vol. 13, pp. 35-40, 2002.

Kramer, M.A., Greiner, M., Koski, J.A. Lopez, C., and Suo-Anttila, A., "Measurements of Heat Transfer to a Massive Cylindrical Object Engulfed in a Regulatory Pool Fire," to appear in the *J. Heat Transfer*.

Refereed Conferences

J. A. Koski, C. Lopez, A. Suo-Anttila, M. A. Kramer, and M. Greiner, "Numerical Prediction of Heat Flux to Massive Calorimeters Engulfed in Regulatory Fires using the Cask Analysis Fire Environment (CAFE) Model," *Transportation, Storage, and Disposal of Radioactive Materials*, PVP-Vol. 408, pp. 117-123, 2000.

M. A. Kramer, M. Greiner, J. A. Koski, C. Lopez, and A. Suo-Anttila, "Design of an Experiment to Measure Heat Transfer to a Massive Object Engulfed in a Full Scale Regulatory Fire," *Transportation, Storage, and Disposal of Radioactive Materials*, PVP-Vol. 408, pp. 125-131, 2000

Kramer, M.A., Greiner, M., Koski, J.A., Lopez, C., and Suo-Anttila, A., "Measurements of Heat Transfer to a Massive Cylindrical Object Engulfed in a Regulatory Pool Fire," *Proceedings of the 2001 National Heat Transfer Conference*, Paper number NHTC01-11466, (Published on CD-ROM, no page numbers), Anaheim, California, June 10-12, 2001.

Ju, H., Greiner, M., and Suo-Anttila, A., "Computer Simulations of a Generic Truck Cask in a Regulatory Fire Using the Cask Analysis Fire Environment (CAFE) Code," *Proc. of*

the 13th International Symposium on the Packaging and Transportation of Radioactive Material (PATRAM), (Published on CD-ROM, no page numbers), Chicago, Illinois, September 3-7, 2001.

Kramer, M.A., Greiner, M., and Koski, J.A., 2001, "Radiation Heat Transfer to the Leeward Side of a Massive Object Suspended Over a Pool Fire," presented at the *2001 International Mechanical Engineering Congress and Exposition*, paper number IMECE2001/HTD-24250 (Published on CD-ROM, no page numbers) New York, NY, November 11-16, 2001.

Kramer, M.A., Greiner, M., Koski, J.A., and Lopez, C., "Uncertainty of Heat Transfer Measurements in an Engulfing Pool Fire," presented at the *Symposium on Thermal Measurements: The Foundation of Fire Standards*, ASTM Committee E05 on Fire Standards, Dallas Texas, December 3, 2001.

Invited Lectures (Not associated with refereed conference publications)

Kramer, M.A., M. Greiner, J.A. Koski, C. Lopez, A. Suo-Anttila, "Measurements of Heat Transfer to a Massive Object Engulfed in a Pool Fire," 5th Thermal Specialists Meeting, Sandia National Laboratories, Albuquerque, NM, October 17-18, 2000.

Ju, H., M.A. Kramer, M. Greiner, J.A. Koski, C. Lopez and A. Suo-Anttila, "Effect of Velocity Boundary Conditions on CAFE Heat Transfer Results," 5th Thermal Specialists Meeting, Sandia National Laboratories, Albuquerque, NM, October 17-18, 2000.

Greiner, M., "Measurements of Heat Transfer to a Massive Cylindrical Object," Chemical and Mechanical Engineering Seminar, University of Nevada, Reno, March, 2001.

Kramer, M.A., Greiner, M., Koski, J.A., Lopez, C., and Suo-Anttila, A., "Measurements of Heat Transfer to a Massive Cylindrical Object Engulfed in a Regulatory Pool Fire," presented at the *2001 ASME Pressure Vessel and Piping Conference*, Atlanta, Georgia, July 32-25, 2001.

Greiner, M., "CAFE Computer Code: A Design Tool for Nuclear Waste Transport Packages," presented at the panel session on Pool Fire Measurement, Modeling and Simulation, *2001 International Mechanical Engineering Congress and Exposition*, New York, NY, November 11-16, 2001

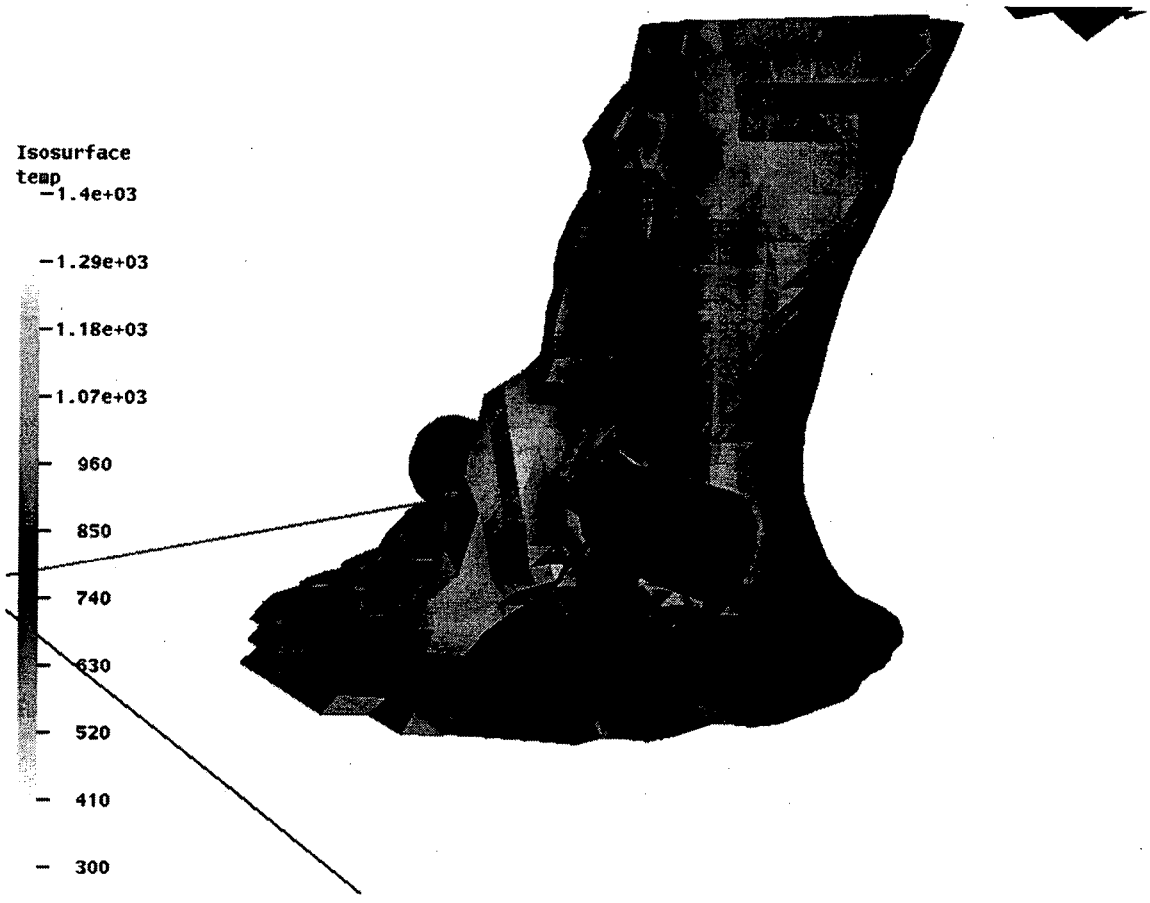

Figure 2. Three-Dimensional Computational Fluid Dynamics simulations of a fire engulfing a massive object with wind performed using CAFE. CAFE will be used in nuclear waste transport design and risk studies.