CAREER: The Role of Turbulence, Coherent Structures, and Intermittency for Controlling Transport in Multiphase Plumes in the Environment

BRYAN ALLDREDGE[1]
[1]*Texas A&M University, Zachry Department of Civil Engineering, College Station, TX 77843, USA. E-mail: bryanalldredge@neo.tamu.edu*

ABSTRACT: Forced vortex break down was the research objective of this international research experience. Particle Image Velocimetry and dye visualization tests were among the results of the trip. Vorticity, breakdown time, and size were all related back to the initial angular velocity of the vortex and how varying this affects the others. However beyond this the international experience provided a much deeper understanding of foreign cultures, and cultured a diverse understanding of peoples not of the United States. Connections were made between this researcher and other fellow researchers, and also between Texas A&M University and the host university. These relationships can be built upon to provide unique learning experiences for all the parties involved.

INTRODUCTION

This International Research and Education in Engineering (IREE) project supplements Dr. S. A. Socolofsky's current National Science Foundation (NSF) project CTS-0348572, awarded to the Texas Engineering Experiment Station, College Station, TX, USA. The award applies advanced laboratory experimental methods to understand turbulence and mixing properties in environmental fluid flows. The educational component of the award develops curriculum in environmental fluid mechanics.

The research shown in this paper was carried out in Karlsruhe, Germany at the Institute for Hydromechanics at the Karlsruhe University. The part of the lab used contained a 1.6m by 1.6m by 10cm water basin with a LaVision camera system for capturing data. Other parts of the lab consisted of a large shallow water basin, and several different types of flowing systems for studying a variety of fluid effects.

The Institute for Hydromechanics (IfH) at the University of Karlsruhe, Germany. IfH is a premier institute conducting environmental fluid mechanics research in an integrated laboratory, numerical, and analytical framework. The institute is comprised of four

divisions (technical hydraulics, turbulent flows, groundwater, and environmental fluid mechanics) and conducts a rigorous research program.

The outcomes of the trip were very broad. Academically, water flow was studied specifically vortex formation, flow and breakdown. Although this was the primary study of the trip, other areas studied include flow of water over a sill driven by a density gradient, and shallow water flow through several types of inlets. Other educational outcomes include learning about different cultures and languages. Several different countries were visited all of which contained their own heritage and language. Connections between co workers, outsider views of our culture, and in depth and first hand learning of several different cultures were some of several experiences gained by researching abroad.

RESEARCH ACTIVITIES AND ACCOMPLISHMENTS OF THE INTERNATIONAL COOPERATION

The accomplishments of the research were plentiful. After analysis the conclusion was that vortex break down does not depend on the initial angular velocity of the vortex. As in it doesn't matter how fast a vortex is initially spinning, it will completely break down in the same amount of time. The size of the affected area of the vortex will be larger, but the higher initial velocities also had a higher initial rate of decay. This decay leveled off over time and when plotted against other initial velocities, converged on a single number at a certain time. Below is a picture of the vorticity fields produced using the PIV, and a graph of vorticity versus time.

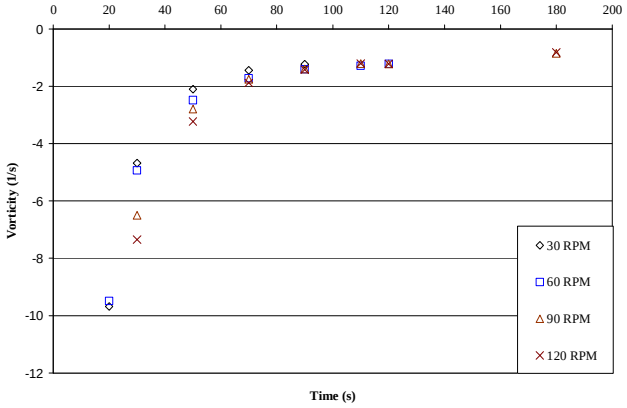

Figure 1. Vorticity of the initial vortex over time.

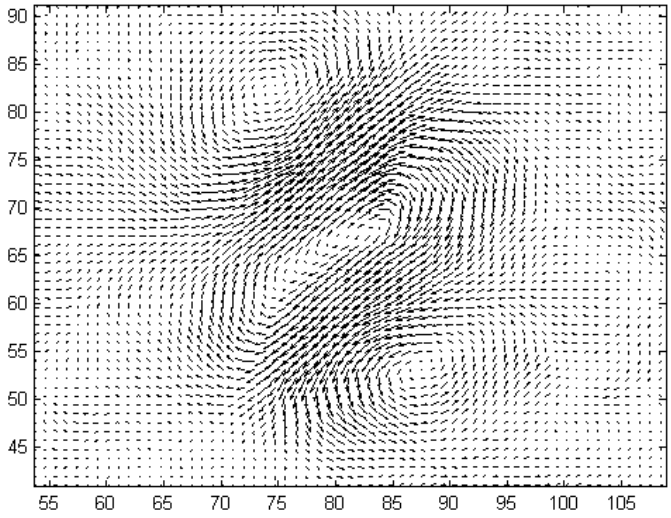

Figure 2. Velocity vector fields.

BROADER IMPACTS OF THE INTERNATIONAL TRAVEL

The summer consisted of 3 months spent in Germany with weekdays spent on the research. Weekends were typically spent either experiencing the local culture or traveling within Europe. The research was focused on the study of vortex breakdown in a shallow water basin. Water measuring 2 cm deep was rotated with a cylinder at varying rotational velocities. The cylinder was removed and the water was allowed to breakdown. This breakdown was documented using a combination of dye visualization tests and Particle Image Velocimetry (PIV) techniques. The water was dyed prior to rotation, white particles added, and then a camera mounted above the basin recorded the breakdown. Using this data, characteristics such as swirl strength and vorticity were calculated and plotted over a time period. The objective of the research was to see how initial rotational velocity affected breakdown times, size and strength of the vortex.

Fellow coworkers were vital to the success of the research. Several different ideas and techniques were consulted from a variety of sources to come up with proper measuring techniques and ideas that would further understanding of vortex breakdown. People from all over the world were there to help with technical questions which my previous education had not yet reached, such as the operation of the camera system and general knowledge of the experimental techniques.

DISCUSSION AND SUMMARY (LIMIT: 1 PAGE)

The trip provided opportunities for many different experiences that can only come from researching abroad. The institution had many different researches from all over the world

including Hungry, France, Budapest, Australia, and Chile. They brought knowledge and techniques from their home countries which helped in coming up with a best fit solution for the research problems on hand. Communicating with these fellow researches also provided insight in to government and laws of their home countries, as well as insights into cultural differences between the US and foreign countries. Many different stories and experiences provided an opportunity to learn about these others cultures and how they live.

The German language was studied as a class prior to going on the trip. It helped with tasks such as ordering food, getting directions or even asking if someone could speak English. Learning part of the language helped immensely with the transition between cultures and helped in getting comfortable doing everyday tasks such as going out to eat, buying groceries, traveling, and going to local events which otherwise would not have seemed inviting. The majority of useful phrases were learned while in Germany however the base to be able to pronounce them was learned prior to the trip.

The research also provided a closer connection between Texas A&M and Karlsruhe University. The schools now know how to setup this type of visitor program and what all must be done to enhance the learning experience for the visiting researcher. The people of the University were already asking that we send someone else next year because the connections are valuable for the visitors and the host alike. It provides for learning that cannot be received studying in the US, such as insight into cultures and widely varying experiences. During the summer several trips were planned over weekends with fellow researchers which gave an opportunity for in depth conversations about government, history, and the research at hand as seen from a different perspective. All of which is valuable knowledge..

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BRIEF BIOGRAPHIES OF RESEARCHERS (SAMPLES BELOW)

Bryan Alldredge is an undergraduate Civil Engineering major at Texas A&M University in College Station, Texas. He is expected to graduate in December of 2008 in General Civil Engineering. Prior work experience includes two summers as an engineering technition at the Texas Department of Transportation.