ILASS – Americas
The Institute for Liquid Atomization and Spray Systems

Newsletter #31 November 2007

A Message from the Chairman

By William Bachalo, PhD

I would like to once again thank the organizers of the 20th ILASS-Americas Conference held in Chicago. The conference was very successful with a record number of attendees and paper presentations.

Thanks to the generosity of Spraying Systems Co. and our many other sponsors (listed on page 3) along with the hard work and organizational skills of Rudi Schick, Conference Chair, and his staff, we all enjoyed a well-organized meeting with exceptional amenities. The banquet at The Field Museum will be remembered for years to come. Shankar Subramaniam, Program Chair, organized a well-planned program. Vince McDonnell once again did a great job ensuring communications were sent out to the membership on time and in setting up the online registration which was appreciated by all. Vince, who is responsible for the ILASS Secretariat, continues to provide this valuable service to the organization. I want to emphasize that ILASS conferences are organized and operated entirely through voluntary efforts. None of the board members or any other members receive compensation for work done for the organization. Thus, the least we can do is express our gratitude for their efforts.

Our next meeting will be chaired by Professor Mark Archambault and held in Orlando, Florida. Professor Terry Parker will act as Program Chair for the conference. In addition to an excellent meeting venue, we can look forward to a visit to the NASA Kennedy Space Center at Cape Canaveral. We will make every effort to continue the careful organization of the meeting to provide a worthwhile experience for all who attend. Our organization continues to grow and attract new members from a broad range of disciplines which ensures conferences that are lively and interesting. Some added attractions are planned for the next meeting and we will inform the membership of these plans when we have them ready.

As we know, atomization and spray research and development represents an important area of study. The growing concern with energy costs and global warming have added to the importance of improving combustion efficiency and emissions reduction. Sprays and spray interaction with turbulent flows are at the core of many of these energy conversion systems. During our last meeting, there were extensive discussions on what we could do as an organization to expand our role in addressing and mitigating energy related problems. Clearly, as Einstein stated, "We can't solve problems by using the same kind of thinking we used when we created them." It is obvious to me that a change in attitude and social behavior is what is needed most if we are to realize the level of reduction in energy consumption and production of greenhouse gases necessary even to begin to correct the problem. As an example, for personal transportation, it is absurd that approximately 95% of the energy consumed goes to moving the vehicle and 5% to moving the individual. Struggling to improve combustion efficiency by a few percent becomes an exercise in futility. With my bicycle, the ratio is 10%

In This Issue:

Our Sponsors:

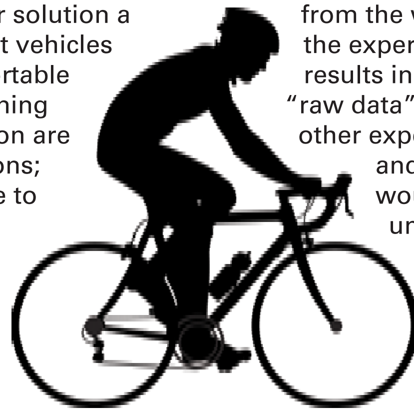
Edited by David P. Schmidt, University of Massachusetts Amherst

Produced by Rudi Schick, Spraying Systems Co.

A Message from the Chairman (cont.)

Rocket Garden at Kennedy Space Center

and 90% to move the rider with the energy coming from excess calories consumed. Hence, cycling also addresses our obesity problem making the latter solution a clear winner. Fuel efficient vehicles providing safe and comfortable transportation while attaining 40 or more miles per gallon are available. We have solutions; we simply need to choose to adopt them.



It is my observation that we are all working to capacity in our chosen fields solving problems that warrant our attention. These problems or challenges are in medical research and development, energy conversion, environmental concerns, food production, industrial applications, defense, and numerous other areas. A percentage of bright individuals must conduct research and develop knowledge in technological areas enabling us to address problems, as yet unknown, which we can be sure, will arise in the future. I am not convinced that we need to nor should we shift our research priorities.

The ILASS Board continues to discuss the possibility of developing a resource wherein our collective knowledge and information on atomization and spray technology as well as related disciplines may be recorded and made available. As stated previously, we need to make information easily accessible in greater detail than can be provided in technical papers. This implies that two paths for knowledge transfer need to be considered; the formal publication in our journal, *Atomization and Sprays*, and a less formal but more extensive publication of information in electronic form such as through Wikipedia. In a review paper that I wrote for *Atomization and Sprays* in 2000, I expressed the need to enhance our methods of publicizing our work and discoveries. I imagined the development of extensive databases with information and experience developed from masses of experiments conducted throughout the world and application of available mathematical algorithms, theories, and artificial intelligence to rapidly access, search, and analyze the results. Building this marketplace of knowledge, information, processing, and storage would avail us to means needed in solving urgent and more complex problems with less time and effort than is possible under our current approach.

Electronic publications are not as limited in space and may include detailed descriptions of experiments, analyses, reduced data from the work, and video clips describing the experiments, computations, and results in detail. Reports may also include "raw data" in a format easily usable by other experimenters, theoreticians, and modelers. This information would serve to enhance our understanding and form evolving databases and libraries of information on spray technology. Analogous to the open source movement in software development, researchers from around the world developing numerical models, instruments, and experiments could work together more closely and even carry out different parts of the experiments simultaneously but at different locations in the world.

Undoubtedly, the end of printed journals and peer reviews is near. Huge amounts of information generated will be too great for human reviewers alone to study and comprehend. The extent of knowledge required to adequately evaluate results will become overwhelming. Electronic publication will allow software algorithms to automatically search existing literature to determine if the work is original, to test the hypothesis, if any, to review results and

conclusions and to test this information against the library of theory and analyses related to the technology. Adopting these methods will take time but I am convinced that the approach is necessary if our area of technology is to grow and lead to solutions of real problems that are confronting us and that will confront us in the future. I am also convinced that the approach will result in an exciting future for young people entering this field.

I look forward to seeing everyone at our next meeting in Orlando, Florida.

ILASS-Americas 2007

The 20th ILASS-Americas Conference was held May 15 through 18 in Chicago. This special anniversary meeting was exceptionally well attended with over 200 registrants. For comparison, attendance has averaged approximately 125 registrants over the past five years. The number of students at the conference, 43, was a new record. Even better, there were 22 students making presentations. In total, there were 82 technical papers and eight posters.

Highlights of the conference were invited talks by C.K. Law from Princeton University and Professor Antonio Cavaliere from University of Naples Federico II. Professor Cavaliere is currently President of the ILASS-International Council.

On Thursday evening, a banquet was held at The Field Museum, home of Sue, the most complete Tyrannosaurus rex fossil yet discovered. The ILASS Simmons and Marshall awards were announced during the banquet. The winner of the Simmons award for a 2006 presentation was "Real-Time Imaging of Fuel Injection, Ignition and Combustion in a Direct-Injected Spark-Ignition Engine" by James D. Smith and Volker Sick. The winner of the Marshall award was "Behavior of a Rocket-Like Coaxial Injector in an Acoustic Field" by D.W. Davis, B. Chehroudi and D.G. Talley. The Simmons award recognizes the best student presenter and the Marshall award recognizes the best non-student presenter.

Professor Shankar Subramaniam, Program Chair, did an excellent job of assembling the conference program. We also owe many thanks to Dr. Rudi Schick, Local Arrangements Chair, who worked to help the conference run very smoothly. And finally, our sponsors deserve our gratitude for making the conference possible: Spray Analysis & Research Services, Woodward Aircraft Engine Systems, Nektar Therapeutics, Parker Hannifin Corp., Goodrich, Solar Turbines, GM, Simulent Inc. and Dow.

Attendees of the 20th ILASS-Americas Conference

ILASS-Americas 2008

The next ILASS meeting will be held in Orlando, FL, May 18 through 21 at the Caribe Royale Orlando. The meeting will be hosted by Professor Mark Archambault, Local Arrangements Chair. Professor Terry Parker will be the Program Chair. The planned location of the banquet is the Kennedy Space Center. The conference web site will be announced via email once it has been posted.

Research Brief

Effects of Finite Sized Particles in Two-Phase Coupling

By Brooks Moses, Stanford University

Although the total drag force or evaporation rate of a droplet may be calculated with relatively sophisticated models, by contrast, the details of the droplet's effect on the gas phase surrounding it are often neglected. This liquid-to-gas transfer is typically applied to the flowfield as a single-point source, based on the assumption that the particle is sufficiently small. However, there are few studies regarding when this "point-particle" approximation is valid, and in many models of the atomization region, it is applied in cases where it would not be expected to be accurate.

As an example, consider the larger, ballistic, droplets in the dense atomization region of the spray from a fuel injector. In a reasonably well-resolved calculation of a combustor, these droplets can have a diameter that is a significant fraction of the size of the grid cell containing them. Also, although they are rare by number count, they have significant contributions to the overall flowfield due to their large size. Moreover, they have significant wakes which take some time to mix with surrounding gas.

Spatially filtering the multiphase flow equations provides a useful approach to this situation. As in large-eddy simulation (LES) of turbulent single-phase flow, the spatial filtering divides the physical flowfield into resolved and unresolved components. The resolved components are those which can be computed directly on the computational grid, and the unresolved components are represented by models of their effects on the resolved scales.

For momentum transfer in incompressible flow around an approximately-spherical droplet, there are two components to a complete model of the droplet's effects on the resolved-scale gas flow. First, there is the forcing term caused directly by the surface stress on the interface, which has a net effect equal to the total drag on the particle. Second, there is a subfilter-scale advection term, which arises because of the unresolved flow structures in the gas around the droplet. Figure 1 shows the spatial distribution of these two terms, for the case of a solid sphere in conditions similar to those for a typical large droplet.

In this framework, then, the point-particle model is simply the assumption that these terms reduce to a filtered point force. In the case of the surface stress, this is a reasonable assumption for any particle with a diameter notably smaller than the filter size. However, this is not nearly as accurate for the subfilter-scale advection term, as Figure 1 shows.

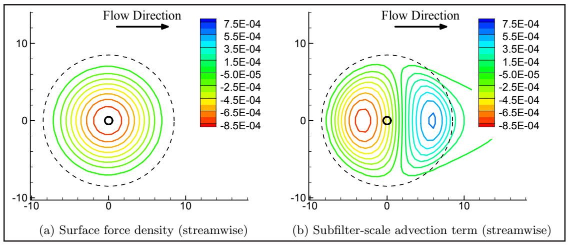


Figure 1: Exact surface force and subfilter-scale advection terms for a spherical particle at Re=100, with a filter radius of 8 times the particle diameter. The scales are nondimensionalized by ρU_0^2. The solid line indicates the true surface location, and the dashed lines represent the outermost extents of the filtered surface location.

A further test of the point-particle model can be obtained by comparing the flowfield that results from the model with the true filtered flowfield. Figure 2 shows these results with plots of the centerline velocity and the viscous dissipation as a function of axial location. (Note that as the flow is filtered across the particle, there is a well-defined filtered velocity inside the particle.) The point-particle model produces significant errors in this case, and we have found that these errors persist even for quite large filter sizes, and for lower Reynolds numbers.

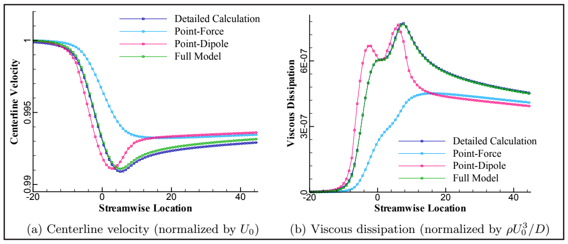


Figure 2: Results for a Re=100 particle with a filter radius of 8 times the particle diameter, comparing the centerline velocity and viscous dissipation predicted by the filtered-point-force model, the combined point-force and point-dipole model, and a complete model to the true filtered velocity and dissipation.

The filtered-multiphase formulation also provides guidance for improved models. For example, if the filtered point force is augmented with a filtered point dipole, as suggested by Sirignano's work on mass transfer [3], the predictions for the centerline velocity values and viscous dissipation are substantially improved. This can be improved further; the subfilter-scale advection term extends downstream into the wake, and if the exact form is used, the predicted flowfield is quite accurate.

[1] Brooks Moses and Chris Edwards, "Beyond the Point Particle: LES-Style Filtering of Finite-Sized Particles", ILASS 20, Chicago, 2007. http://dpdx.net/research/ILASS2007.

[2] Brooks Moses, Simulation of Multiphase Fluid Flows using a Spatial Averaging Process, Ph.D. Dissertation, Stanford University, 2007. http://dpdx.net/research/thesis.

[3] William A. Sirignano, Fluid Dynamics and Transport of Droplets and Sprays, Cambridge, 1999.

The Breadth Column

Spray Nozzles in Firefighting

By Adam Barowy, WPI

This is a column devoted to subjects tangentially related to sprays. The editor welcomes short submissions on as broad a subject matter as possible.

There are two basic categories that classify the nozzles used in the fire service, "smooth bore" nozzles and "combination" nozzles. Smooth bore, fixed orifice, nozzles are the most basic design, providing only a single jet but also requiring the least amount of nozzle pressure to produce an effective stream. Smooth bore nozzles have typical orifice diameters from 15/16" to 2.75", are designed to operate between 40-100 psi and are capable of ranges from 100 ft to 260 ft. This type of nozzle is employed on hand operated hose lines for interior fire fighting, typically running at a pressure of 100 psi with a reaction force of 80lb. Smooth bore nozzles are also mounted on vehicles when high discharges (up to 2010 gpm) are needed to control large fires. The low pressure design of a smooth bore nozzle makes it advantageous in a high rise fire where it is often difficult to obtain the operating pressure required for combination nozzles.

The design of the combination nozzle allows the nozzle operator to infinitely adjust the spray pattern from a single coherent stream to a wide angle fog, making it more versatile. Like the smooth bore nozzle, high discharge combination nozzles are also vehicle mounted. The drawback of the combination nozzle is that its design requires a higher operating pressure to produce a fully developed spray pattern. This results in a higher nozzle reaction force than a smooth bore nozzle. Simple combination nozzles are designed to operate at one pressure with one flow rate available. More expensive and complex designs may operate at a single pressure with selectable flow rates from 5-250 gpm or automatically adjust their flow rate to maintain a designated operating pressure. The coherent stream produced by a smooth bore or combination nozzle is useful in extinguishing fire while minimally upsetting the thermal balance in an involved room because it does not evaporate as readily as a less dense stream. Less dense streams can also have the adverse effect of producing scalding vapor. Unlike the smooth bore, the combination nozzle can also be used on a fog setting to forcefully ventilate the products of combustion to cool a room and increase its visibility. Additionally, fog patterns can be used to cool immediate exposures to fires or to control the direction of gas clouds during hazardous material emergencies.

Mr. Barowy is a graduate student in WPI's fire protection engineering program and was previously a volunteer firefighter.

Board Member Profile

Corinne Lengsfeld

Corinne Lengsfeld has been a member of ILASS since 1995 and was elected as a board member in 2005. She initially became a member to increase her professional network in the spray community and receive critical feedback on the research she was conducting in this area. Corinne began co-chairing the physics of atomization technical committee in 1997. The service activities have enhanced her professional career by offering opportunities to see and practice leadership skills. However, it is the students and industry people who come to ILASS to learn that drives her passion for service.

Corinne is Associate Professor of Mechanical Engineering at University of Denver and earned her PhD at University of California, Irvine. Her specialties include spray atomization, super critical fluid behavior, pharmaceutical processing and drug delivery. Corinne currently also holds a graduate faculty appointment in the Department of Pharmaceutical Sciences, University of Colorado Health Sciences Center.

The Benefits of Membership in ILASS-Americas

Sometimes it is easy to take things for granted — and we all do it from time to time — but we'd like to take just a moment to review the benefits you experience as a member.

- Annual conferences offer the ideal environment for staying on the leading edge of technology and networking.
- Seven technical committees are hard at work developing industry standards, identifying emerging technologies and promoting exchanges of information between the world's leading experts. Be a part of it!
- Do you have a specific problem you'd like to discuss with your peers right now? Log onto the ILASS-Americas' Discussion Board, where you can instantly network with other experts in your field.
- The ILASS newsletter keeps members apprised of upcoming events so you won't miss important educational opportunities and technical articles.
- Our Harold C. Simmons and W.R. Marshall awards recognize and encourage the next generation of industry experts. Can you recommend any worthy candidates?

Encourage someone to join ILASS-Americas

Membership in ILASS-Americas is affordable for all. A one-time $20 membership fee is all it takes to tap into the resources and benefits just noted. Why don't you take just a moment and encourage your colleagues and associates to consider joining? You'll be ensuring the continued growth and longevity of our professional association.

To become a member of ILASS-Americas, complete the application below and mail to:

Professor Scott Samuelsen
Secretariat, ILASS-Americas
UCI Combustion Laboratory
University of California
Irvine, CA 92697-3550

Membership Application Form

I wish to become a member of ILASS-Americas. I enclose a check/money order for $20.00 in U.S. currency payable to "ILASS-Americas." (Please print or type full name, title and mailing address.)

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