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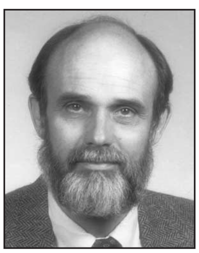
FED

Richard R. Schultz, Editor

Spring 2001

Chair's Message



David E. Stock

During the past year, the Fluids Engineering Division (FED) held its annual summer meeting (FEDSM 2000) in Boston and sponsored sessions at the 2000 ASME International Mechanical Engineering Congress & Exposition (IMECE) in Orlando. Both meetings were organized in a bottom-up format typical of all FED meetings. At the technical committee and coordinating group (TC/CG) meetings, members suggest topics for symposia and forums. These suggested topics are discussed and, if sufficient interest is shown, a committee is formed to organize the symposium or forum. This committee is responsible for writing a call for papers. New members are usually teamed with experienced members in the organizing committee. After the call for papers has been approved by the TC/CG, the chair of the TC/CG submits the draft call for papers to the Executive Committee of the FED. The Executive Committee is responsible for ensuring the suggested symposia and forums have sufficient diversity of topics and sequencing. A member of the Executive Committee will be assigned the responsibility of chairing the conference. The conference chair will work with the symposium and forum chairs to coordinate advertising, paper submission, and scheduling. In summary, the first step to becoming involved in the planning and organizing of an FED meeting is to come to a committee meeting. Remember that attendance and membership in an FED technical committee or coordinating group is open to all interested parties.

The four-day FED Summer Meeting in Boston in June 2000 had an attendance of 400 and included 90 technical sessions. The meeting also featured four plenary presentations and five tutorials. The two-hour tutorials gave participants an opportunity to gain in-depth knowledge about a specific topic. Topics included hydraulic design of centrifugal compressors, parallel computing, computational fluid dynamics, particle velocimetry, and turbulence modeling. Most attendees found the Sheraton Hotel in the center of Boston an ideal location for the meeting, with food courts and shopping in the same building, a wide assortment of small restaurants within easy walking distance, as well as excellent jogging paths along the Charles River.

The IMECE was held at Disney World in early November. Most divisions of ASME take part in this meeting. FED sponsored 35 technical sessions, the Freeman Scholar Lecture by Professor Yogesh Jaluria, and a reception. We also co-sponsored sessions with other divisions. At the TC/CG meeting, new chairs and vice

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Journal of Fluids Engineering

Transition of Editors and Associate Editors

As the readers have been informed in the last issue of this newsletter, Professor Demetri Telionis has recently completed his 10-year tenure as the technical Editor of JFE. I would like to take this opportunity (my first article in the *FED Newsletter*) to thank him and to highlight the enormous contributions that he has made to the quality and breadth of this journal. I am very honored and challenged by the tasks of following in his footsteps and living up to his legacy. I am looking forward to continuing and expanding the service that this journal provides to the fluids engineering community.

Under Professor Telionis leadership, the past 10 years have been characterized by the transition process and progress in electronic publishing. Articles and abstracts are now available on-line. In addition, Prof. Telionis established the JFE Data Bank in 1993 and progressed to an on-line version with downloadable information from authors. The last ten years are also characterized by technical innovations designed to meet the needs of readers and authors from both industrial and academic backgrounds. The journal included industrial discussions and

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Chair's Message

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chairs started their two-year terms. IMECE provides an excellent opportunity for members of FED to meet with the members of other divisions, including Heat Transfer, Manufacturing, Materials, MEMS, and others. Disney World provided an excellent venue for a meeting-warm evenings to sit outside and continue a technical discussion and sunny early mornings for a jog along the water before the sessions start.

It is the Executive Committee's responsibility to plan and execute technical meetings that provide a format for our members to exchange technical ideas and to learn of new advances in a field. But we depend on the members to point us in the right direction through their participation in committee meetings and through personal contact with either a chair of a TC/CG or a member of the Executive Committee.

The FED summer Meeting 2001 will be held in New Orleans on May 29-June 1. Details of the technical sessions and committee meeting schedule can be found at the ASME web site for the meeting: http://www.asme.org/conf/fed01/. Review the plenary talks, the tutorials, and the technical sessions and I am sure you will find the meeting has a lot to offer. The meeting was scheduled a little earlier than usual so that we could enjoy New Orleans before the hot weather arrives. I hope to see you at the meeting.

The FED's *Journal of Fluids Engineering* (JFE) provides another mechanism for the distribution of the work of fluid engineers. Our new editor, Professor Joseph Katz, continues work to increase both the quality and size of the journal. You should consider the JFE as your journal. Submit your work to the journal and turn to the journal as your first source of information on a topic related to fluids engineering. If you present your work at an FED meeting, you should be sending your paper to JFE. Joe is anxious to have the journal publish papers on all the topics covered by sessions at our meetings.

David E. Stock, Chair,
Fluids Engineering Division
Washington State University

FED Members Elected to Fellow Grade

Shmuel Einay
David Japikse
Yiannis Andreopoulos
Eric Zimmerman
Sung Ling
Ronald Coffield
Donald Webb
Sastry Munukutla

Journal of Fluids Engineering

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extended review articles on several topics. Several volumes contained themed topics in specific areas and Technical Forums featured extensive backgrounds on specific issues.

Under Professor Telionis guidance efforts have been continuously made to enhance the quality of papers published in the journal. A policy requiring inclusion of experimental uncertainty in papers containing experimental data has been established. Standards for numerical accuracy have also been adopted. We are committed to maintaining and expanding these standards as new techniques and technologies become available. Professor Telionis also attracted teams of high quality Associate Editors who are renowned experts in their fields. Their contribution has been a critical component in maintaining the quality of the papers published in the journal. Demetri also made special efforts to attract authors of quality JFE conference papers to submit their manuscripts to the journal. Such an effort is an inspiration for our future efforts and it has led to a considerable increase in the number and quality of submitted papers.

In addition to his excellent service as an Editor, Professor Telionis has consistently maintained a well-funded and internationally visible research program. His contribution is attested to by the large numbers of publications in prestigious journal, mainly in the area of unsteady flow mechanics, a field in which he is a renowned expert. His service includes also consultancies, panel review memberships, invited keynote lectures, session chairmanships at meetings, one patent and two teaching excellence awards. Professor Telionis has also found time to start a company (Aeroprobe Corporation) and write two outstanding textbooks, "Unsteady Viscous Flow," published by Springer-Verlag in 1981, and "Nonsteady Fluid Dynamics," published by the ASME in 1990.

Finally, I would like to thank Demetri and his Editorial Assistant; Mrs. Pat White for guiding us through the transition process and insuring that it is smooth. Demetri's involvement in JFE has not ended. He is now a senior member of the ASME Publication Committee that oversees all the ASME Journals. In this position he has provided valuable advice and communication lines with the senior personnel at ASME headquarters that administer the journals.

Three Associate Editors have completed their terms during the past year. I would like to take this opportunity and express my gratitude to them. The valuable service of the Associate Editors is critical for the success and reputation of a journal. Besides the essential technical knowledge the job requires a considerable investment of time, and the willingness to perform tasks, which are not always a pleasure (such as nagging referees to provide reviews in a timely manner, "harassing" authors to complete revisions and negotiating conflicting reviews). This service and support are greatly appreciated. Professor Peter Bradshaw has provided his unparalleled experience and expertise in all aspects of turbulent flows, particularly in turbulence modeling. Professor David Williams has been our expert in boundary layers, wakes, separated flows and and flow control. Dr. Frederic K. Wasden has provided a unique perspective that combines industrial experience in the chemical engineering industry and a background in multiphase flows, interfaces, liquid films and related nonlinear dynamics.

Several new Associate Editors have joined us, some at the beginning of 2000 and the rest have been appointed recently. We have already "taken advantage" of their valuable services.

The Associate Editors that have joined about a year ago are:

Professor Juan Lasheras, University of California, San Diego. Originally from Spain, Professor Lasheras received his Ph.D. from Princeton University. He is a well-known expert in multiphase flows, turbulence and experimental fluid mechanics.

Bruno Schiavello, Ingersoll Dresser Corp. Mr. Schiavello graciously agreed to serve a second continuous term, continuing his valued service and generous use of his time. Educated in Italy and Belgium, he is our industrial expert in pumps and pump fluid dynamics.

Professor George Karniadakis, Brown University. Educated at MIT, Professor Karniadakis is a well-known expert in all aspects of CFD and numerical techniques. This will be his second (non continuous) term as Associate Editor of JFE. We hope to use his expertise in re-establishing quality standards for papers containing CFD results.

Professor Yoichiro Matsumoto, University of Tokyo. Professor Matsumoto received his Ph.D. from the University of Tokyo. He has vast experience in modeling of multiphase flows and molecular dynamics. He has also been very active in the fluids engineering and multiphase flow communities.

Ms. Lisa Mondy, Sandia National Laboratory. Alumna of Rice University, Ms. Mondy has decades of experience working in multiphase flows involving solid particles, flow in porous media, both computationally and experimentally.

Professor Yoshinobu Tsujimoto, Osaka University. Educated at Osaka University, Professor Tsujimoto is a renowned leader in the turbomachinery community, particularly in problems related to instabilities

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in pumps. He has also been very active in organizing symposia world-wide.

Dr. James Bridges, NASA Glenn Research Center. Dr. Bridges received Ph.D. from University of Houston, and has spent over 10 years working with NASA. He is an expert in all aspects of applied fluid mechanics and acoustics, including measurement techniques. He also has background in hydrodynamics, vortex dynamics and turbulence.

At the beginning of 2001 we are joined by five additional Associate Editors:

Dr. Edward Graf is presently the head of the Computational Development Group at Flowserve Pump Division. A recipient of many awards, Dr. Graf has almost thirty years of experience in studying a wide variety of problems in aerodynamic, hydraulic and acoustic design as well as in design of advanced of turbomachines.

Professor Ismail Celik, West Virginia University. He is an expert in CFD, including heat transfer, multiphase flow, combustion, numerical uncertainty, turbulence modeling and application of variety of commercial CFD codes. He has been active in the Fluid Engineering Division of ASME, and has considerable experience in consulting.

Professor Jeffrey Marshall, The University of Iowa. He specializes in vortex dynamics, fluid-structure interactions, vortex turbulence and two-phase turbulent flows. He has made substantial contribution to the development of Lagrangian computational methods.

Professor Ajay Prasad, University of Delaware. He is predominantly an experimentalist with substantial experience in development and application of Particle Image Velocimetry, and its application to flows in complex geometries.

Dr. Thomas B. Gatski, NASA Langley. He is a leader in the field of applied aerodynamics, and has extensive experience in implementation of state of the art turbulence levels in complex flow computations. He is considered to be a renowned expert in the modeling of turbulence, both in fundamental and at applied levels.

With such a team of new Associate Editors, that joins an equally impressive group that has already served for the past several years, my job is made relatively easy. I wish to thank all of them for agreeing to serve, and promise to take advantage of their expertise as much as I can.

As for the future, our primary objective is to maintain and enhance the quality and reputation of the journal that would make it attractive both to authors and readers. We will continue introducing special topics and pursue extended review articles of interest to community. We would also like to enhance our ties with the Fluids Engineering Division community and increase the contributions of participants in these meetings to the journal. We also plan to revisit our standards for accuracy and uncertainty as new technologies and tools become available. The recent transition to a new publisher and the availability of online manuscripts are some of the indicators that technical publishing, including JFE, is in a period of transition characterized by the increasing role of electronic publishing. We plan to adapt to this new age also during the reviewing process. Manuscripts posted on the Web can become accessible to referees shortly after submission, all through email communication. We plan to make such a mode of communication available to authors, Associate Editors and referees very soon. This process will be part of an effort to expedite the reviewing process. We hope that a faster review process would make JFE more attractive to authors and the readers.

Prof. Joseph Katz
Editor of JFE
Johns Hopkins University

Government Relations

A primary mission of ASME lies in its contribution to the policy making process by providing government decision-makers with technical information needed to make the most informed decisions on technical and related issues. To this end, ASME devotes much of its resources toward government relations. ASME International's government relations program is directed at affecting the outcome of issues identified by members as important to the practice of mechanical engineering in the public interest. Under the direction of the Board on Government Relations, the program is conducted through a framework of activities aimed at identifying issues and strategies; informing the ASME membership; involving society members through a variety of programs for individuals and groups; preparing and presenting position statements, testimony, and technical briefs; and holding meetings with policymakers.

Topics of interest to ASME International include energy, environment, education, research and development, technology policy, and professional issues. The Society prioritizes specific issues-both at the federal and state levels, to be addressed and publishes them in the Public Policy Agenda of ASME.

ASME members have many opportunities to participate in the Society's government relations activities. Divisions, Sections, and Regional operating boards have government relations chairs to guide and coordinate activities. The FED Government Relations Committee was formed in the fall of 2000 and will coordinate Division activity under the auspices of the FED Executive Committee and the Vice President for Basic Engineering. The committee is currently composed of the following members:

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The committee will meet during the 2001 FEDSM in New Orleans, LA to more clearly define roles and responsibilities. All interested FED members are invited to participate. In addition, individual ASME members have the opportunity to compete for federal and state government relations fellowships. Each year, members are selected to serve for one year on the professional staff of a U.S. senator or representative, a congressional committee, the White House Office of Science and Technology Policy, the National Conference of State Legislatures, or a state legislative/executive science, engineering and technology office.

For more information on ASME Government Relations activities and opportunities, please visit the web page at http://www.asme.org/gric/.

Tech Brief: Axial Fan Research for Automotive and Building Ventilation Applications

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INTRODUCTION

Axial fans provide airflows over an extremely large range of flow rates and pressure rise values. Their distinguishing feature is that the pressure rise will be relatively small and the flow rate relatively large in comparison with prime movers of other designs, e.g., cent-axial and centrifugal. Numerous general discussions of axial fans exist; the following are among those that can be recommended: Wallis (1961), Osborne (1966), and Bleier (1998).

The present communication is to provide a focus on two classes of fans that have been investigated in the writers' laboratory. These two classes can be described in terms of the application areas served: automotive engine thermal management and agricultural building ventilation. The importance of the former is apparent when one realizes that nominally one-third of the released energy in the combustion process must be transferred to the ambient air through the cooling water jacket and the radiator. (Air conditioning and auxiliary heat exchangers add to this thermal "load".)

Numerous factors make prediction of the underhood cooling flows a most challenging task. Among these are the influence of the upstream restrictions on the fan performance and the blockage elements that exist downstream of the fan. Lifting the hood on a modern passenger car will immediately clarify this issue. These complexities and the importance of properly addressing them has provided the motivation for auto manufacturers to invest in detailed investigations of these flows. As specific examples, the writers' efforts have been supported by the Ford Motor Co. (now including Visteon, Inc.) and Daimler-Chrysler; some of the results from these investigations are presented below.

Axial fans found in agricultural applications include those used in greenhouse and livestock building ventilation. Heat and moisture removal, along with the discharging of contaminated air are the primary issues for these ventilation systems. Two specific applications, poultry and swine production are described below.

Poultry buildings are typically 18 m (60 ft) wide × 122 m (400 ft) long and house 100,000 birds. In these buildings, air is exhausted via an array of axial fans located along the width of one end. Clean air is then drawn in through the opposite end, where it is either cooled via evaporative heat exchangers or conditioned through a series of filters. This system is termed "tunnel ventilation". During the summer months, heat removal is critical; it can be readily appreciated that a failure of the airflow system would cause catastrophic losses as the temperature in the building would dramatically increase with 100,000 birds serving as localized heat sources, producing 7.2 watts/bird (or 12 BTU/hour/bird). During the winter months, heat removal is less of a concern, but moisture removal and oxygen replacement become increasingly important. Egg production and weight gain (meat) are adversely affected by increased temperature and decreased amounts of fresh air. For the farmer/producer, enhanced air-moving efficiency will translate directly into increased profits given that the fans account for nominally 50-60 percent of the operation's total costs.

The size of a swine building varies depending on the stage of the animals' development (the swine are moved into different buildings as they grow). For the "finishing" stage, which is the final stage and thus houses the swine at their largest size, the building is typically 12 m (40 ft) wide × 60 m (200 ft) long and houses 1000 animals. In these facilities, heat and moisture removal are the most critical issues in the summer; in the winter, moisture and ammonia removal (a potentially suffocating by-product from the animal's waste), along with oxygen replacement are the most important considerations. It is noted that "cleansing the discharge air" is both environmentally friendly as well as costly in terms of the additional pressure rise across (or power input to) the induction fans.

The limited profit margins in these facilities places a premium on the cost effective provision of the needed airflows. This motivation led to Phase I and Phase II USDA/SBIR contracts to Digital Flow Technologies, Inc. (DFTI) with subcontracts made available to the writers' laboratory. A leading manufacturer of such fans: Aerotech, Inc. of Mason, MI, has partnered with DFTI to commercialize these developments. The USDA and the Aerotech, Inc. support has also led to the results summarized below.

GENERAL CONSIDERATIONS REGARDING AXIAL FANS

The essential character of an axial fan is revealed by a lifting surface (an airfoil) that is translating in a quiescent medium. Following the passage of the surface, the drag experienced by the surrounding fluid will lead to an in-line component of velocity and the lift on the surface will produce a corresponding momentum flux in the direction opposite to the lift.

If the lifting surface were a fan blade, these motions could be resolved into the azimuthal and axial velocity components downstream of the fan. Since the airfoil sections experience a translation velocity of magnitude ($\Omega \times R$), and since the blade will not have a uniform shape for all (R), the induced velocities may be a complicated function of R. Concomitant effects, developed by the centrifugal ($-\Omega \times \Omega \times R$) and the Coriollis ($-2\Omega \times V$) "force" effects and augmented by a pressure rise across the fan plane, will lead to a radial velocity component in the induced motion. It is useful to note that the technological motivation for an axial fan: "to move fluid from the upstream to the downstream domains" is primarily achieved by the axial component. A positive radial component, depending upon the fan/shroud geometry, may also contribute to the mass flux. The azimuthal component simply represents an "energy sink".

The standard description of a fan's performance is given in terms of the pressure rise (ΔP) as a function of the flow rate (Q). These variables are best considered in dimensionless form. The length and velocity scales most commonly used are the fan diameter (D) and tip speed (U_{tip}), respectively. The pressure coefficient:

$$\psi = \Delta P / \rho U_{tip}^2 \qquad (1)$$

and the flow coefficient

$$\phi = Q / (\pi D^2/4) U_{tip} \qquad (2)$$

are defined to provide a new functional dependence: $\psi = \psi(\phi)$. For a given blade shape, this relationship will be valid for a wide range of fan sizes and speeds. This reflects the insensitivity of the flow field to the Reynolds number. That is, the non-dimensional velocity and pressure fields are dominantly controlled by inertial effects and the imposed boundary conditions; they are insensitive to viscous effects. The above dimensional reasoning leads to what is conventionally referred to as "fan laws". Specifically, the scaling of dependent variables which are independent of Reynolds number provides a set of standard relationships commonly found in the literature and texts.

Figure 1 shows a typical automotive cooling fan installed in a test configuration. The geometrical configuration for this test is referred to as a 'free inlet-free outlet' or FIFO condition. This configuration is used to benchmark fan performance without the effects of blockage elements. The latter, which are in close proximity to the installed fan, significantly affect its performance.

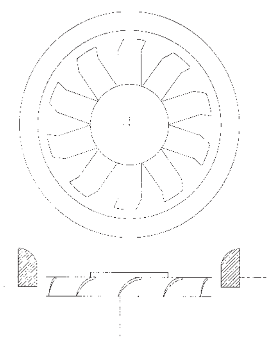

Figure 1. A typical underhood cooling fan in a shroud that permits the free inflow/free outflow (FIFO) condition to be examined.

Figure 2 shows a typical building ventilation fan. This 0.67m (26.5-inch) diameter fan is typical of the fans that would be found in hog buildings. The performance is also typical in that a relatively low pressure rise and high volume flow rate are provided. Several aerodynamic differences exist between the automotive and ventilation fans which lead to these different performance characteristics. Specifically, the number of blades, hub-to-tip ratio, and solidity are design parameters which play an important role in a fan's performance and all of these are larger for the automotive fan.

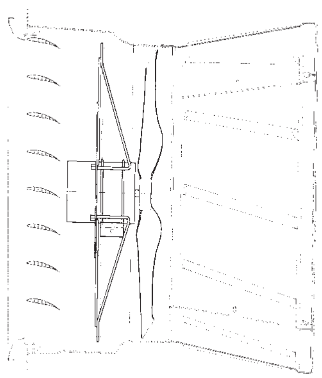

Figure 2. Aerotech 26 inch axial fan with inlet shutter and diffuser cone.

A variable which is also of considerable interest is the fan efficiency. Unlike performance, the definition of efficiency depends on the specific application of the fan. For automotive cooling fans, the chosen velocity and length scales are used to normalize the input power. The definition of efficiency follows (where ρ_{shaft} is the power delivered to the fan's drive shaft):

$$\eta = \frac{\Delta P Q}{P_{shaft}} \qquad (3)$$

The ventilation industry typically defines efficiency as a dimensional number: flow rate/input power. This is usually expressed in CFM/Watt.

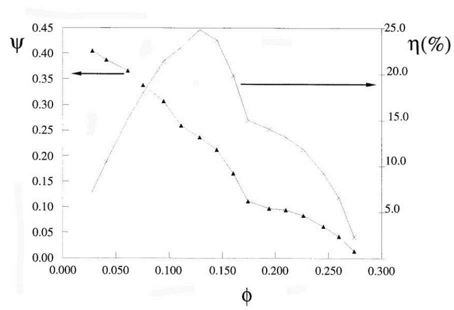

Figure 3. The nondimensional pressure rise (ψ) and efficiency (η) as a function of the nondimensional flow rate. Note, see equations 1, 2 and 3 for ψ , φ and η.

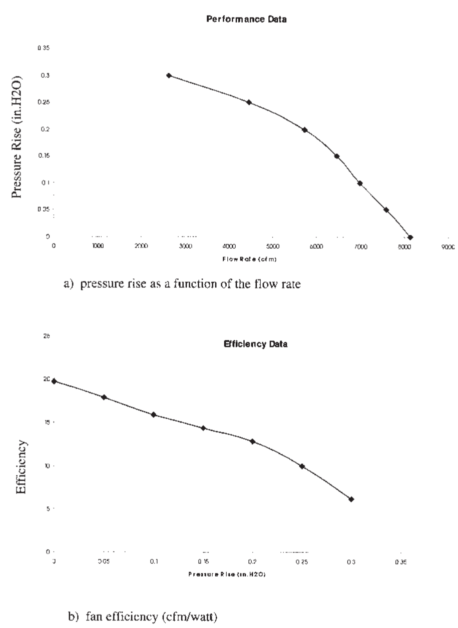

Figure 4. Performance data: the aerotech fan assembly of Figure 2.

THE AXIAL FAN RESEARCH AND DEVELOPMENT FACILITY

Figure 3 presents the performance ($\Delta p \sim Q$) and the efficiency data for the fan/shroud combination of Fig. 1. These data are presented in non-dimensional form which would permit their extension for other rpm values (1000 rpm was used for the plot) and for other geometrically similar configurations. The experimental data for Figure 3 were acquired in a unique facility: the Axial Fan Research and Development (AFRD) facility located in the Turbulent Shear Flows Laboratory at Michigan State University. Similarly, the performance and efficiency data (Figure 2) are presented in Figure 4. This flow

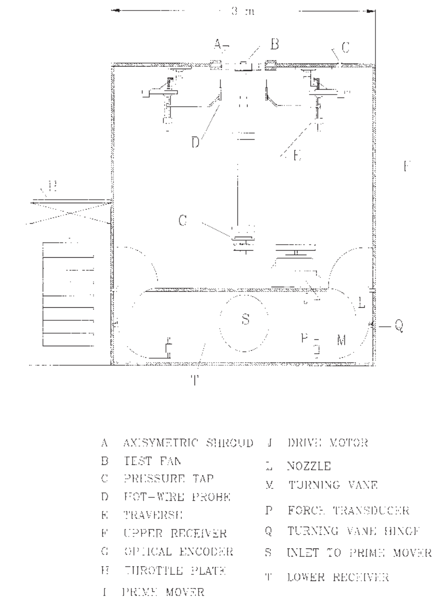

Figure 5. A schematic representation of the aeroshroud. Note, a typical engine mounted fan is shown in this figure. (Drawing is to scale).

system is shown in Figure 5.

Laboratory air is delivered through the test-fan-plane into the upper receiver of the AFRD. The corresponding Δp is easily measured via the indicated pressure tap. A novel moment-of-momentum flux device (see Fig. 6 and Morris, et al. (2000)) is used to determine the volume flow rate delivered by the test fan against the back pressure of the upper receiver. This pressure is controlled by the throttled condition of the large centrifugal fan which exhausts the lower receiver of the AFRD. This complete system has been fully described in the MS thesis by Morris (1997).

The favorable attribute of the moment-of-momentum flux flow meter is its insensitivity to the approach flow condition. This is

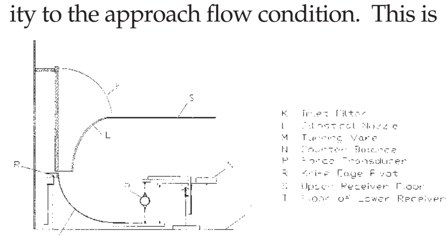

Figure 6. The moment-of-momentum flux device that is used as the flow rate metering technique in the AFRD.

important given the large variations that are experienced in the AFRD. Specifically, the unobstructed flow from the fan will be downward to the floor of the upper receiver and it will horizontally enter the nozzle contraction. Conversely, an obstructed fan flow (e.g., a simulated engine which blocks the fan flow) will enter the nozzle from the outer walls of the upper receiver.

A 15 HP, ±1% speed controlled drive system is used to power the automotive cooling fans. This drive train includes a torque meter that permits an accurate ±0.15% of full scale) measure, when combined with the fan's rotational speed of the delivered power. Independent electrical measurements allow the drive train losses to be assessed and they provide a consistency check on the direct power measurement.

Detailed hot-wire surveys can be executed in the outflow from the fan. For these, a calibrated x-array of hot-wire sensors is aligned with the time mean flow direction that has been independently determined using the technique described by Morris (1997). A three-dimensional probe alignment device (see Fig. 7) is used to support the probe shaft with the correct spherical angles of the time mean velocity. The time series data (E_1, E_2) then allow $u(t)$ - plus - $v(t)$ and, with a 90-degree rotation about the probe axis, $u(t)$ - plus - $w(t)$ to be acquired. These Cartesian components: u,v,w are referenced to the "probe coordinates" for each measurement. The time resolved velocity data can be used to recover the time mean, the fluctuation intensities, and the kinematic Reynolds shear stress quantities in the axial, tangential directions if the probe is in this plane for the u,v measurements. (This is the condition for the data presented below). The time mean and fluctuating intensity data for the radial velocity component follow from the u,w data given the same constraint.

Figures 8 and 9, which were obtained using the configuration of the next section, are included here as demonstrations

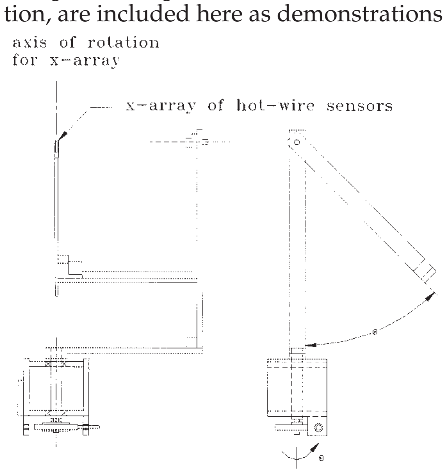

Figure 7. The spherical angle position device which allows x-array hot-wire measurements to be aligned with the time mean wake flow at a given r/R position.

of the level of detail that can be obtained from the measurements described above. These data have been abstracted from Morris (1997) and the manuscript that has been submitted to *JFE*: Morris and Foss (2000). One quadrant of the full data set is shown. These phase sampled data are referenced to the fan's angular position (θ) by an optical encoder which is reset

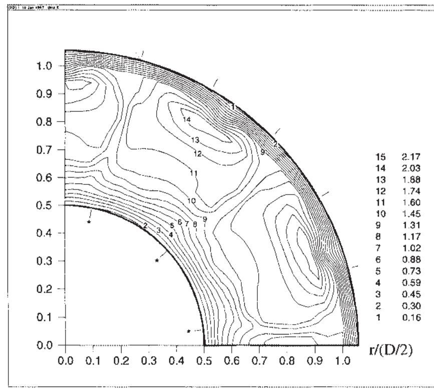

Figure 8. Contours of phase averaged axial velocity: U_x/U_{tip}. Note: Blade rotation is clockwise.

(n=0,1,2...N) for each revolution. The ensemble averaged data represent 900 independent samples, i.e., N=899.

Note that the signatures of the blades are well resolved in these data. The spatially differentiated $v_r(r,\theta)$ and $v_\theta(r,\theta)$ data permit the axial vorticity

$$\omega_x = \frac{\partial v_\theta}{\partial r} + \frac{v_\theta}{r} - \frac{1}{r}\frac{\partial v_r}{\partial \theta} \qquad (4)$$

to be determined. The wingtip vortex motions are clearly evident in Fig. 9.

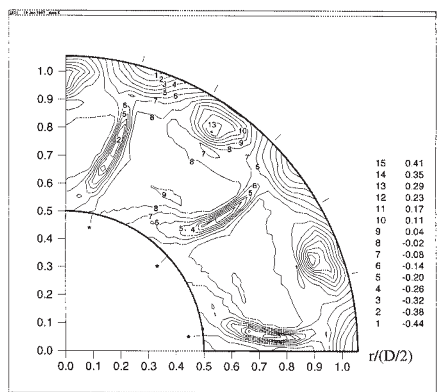

Figure 9. Contours of phase averaged axial vorticity: ω_x/DU_{tip}. Note: Blade rotation is clockwise.

THE AERODYNAMIC SHROUD (AN MSU INVENTION)

The aerodynamic shroud, shown schematically in Fig. 10 and described by Foss (1998) and Foss and Morris (1999), provides two distinct benefits for the axial fans considered in this communication. An engine driven fan must be configured with a large tip clearance given the relatively large (≈25mm) motion between the chassis mounted shroud and the engine mounted fan. A concomitant result of this condition is the presence of large "tip region losses" or flows from the pressure to the suction side of the blade in the tip region. A ventilation fan will typically operate with a small tip clearance, but the downstream diffuser cone is vulnerable

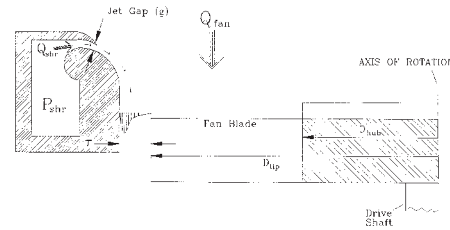

Figure 10. A schematic representation of the aeroshroud. Note, a typical engine mounted fan is shown in this figure.

to flow separation effects given the limited energy that can be supplied to the boundary layer fluid by the fan. In both of these conditions, the enhanced axial momentum at the fan plane, as provided by the Coanda jet of the aeroshroud, leads to improved system performance. A recent study by Neuendorf and Wyganski (1999) has identified the benefits of using a properly shaped inlet shroud contraction. Their identification of an enhanced entrainment for a curved surface wall jet will be investigated in our search for an improved aeroshroud design.

The beneficial influence of the aeroshroud on the automotive fan's performance is clearly shown by the $\Delta p \sim q$

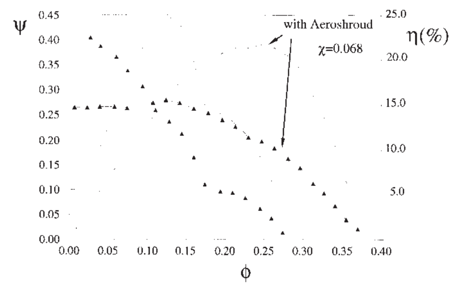

Figure 11. Enhanced cooling fan performance with the aeroshroud of Figure 10. Note, χ is defined in equation 5.

curves of Fig. 11. Morris (1997) showed that the product of the aeroshroud's flow rate and pressure rise - i.e., its power - correlated the performance data. This product, suitably non-dimensionalized, is shown as the parameter X in Fig. 11. Its definition is:

$$X = \Delta PQ / \rho A_{flow} U_{tip}^3 \qquad (5)$$

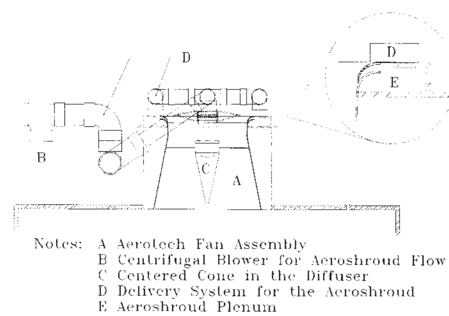

Figure 12. Aeroshroud configuration for the 26 inch fan of Figure 2.

Table 1: Performance improvements for the ventilation fan that has been fitted with an aeroshroud

	Without Aeroshroud	With Aeroshroud	%Difference
Q	61.5	79.5	29.2
Efficiency	15.9	16.8	6.11

Significant performance improvements were also experienced in the ventilation fan studies. The configuration, shown in Fig. 12, when fitted with an active aeroshroud, achieved the performance improvements shown in Table 1. These numerical values represent a pressure rise condition of 0.1 inches of water; however, similar gains were observed for all pressure rise conditions.

Note, the efficiency improvement was assessed using an estimated 70% efficient centrifugal fan to pressurize the aeroshroud. Also, since the inflow to the aeroshroud can be taken from the building to be ventilated, the figures in Table 1 include the shroud flow rate in the enhanced Q value.

SUMMARY

Axial fans are utilized in a wide range of applications. Two of these: underhood cooling fans and building ventilation fans have been considered in this communication. The writers' capability to execute detailed velocity measurements, as well as performance measurements, has been demonstrated. An MSU invention: the aerodynamic shroud, has been shown to enhance the performance of both styles of fans.

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Fluids Engineering Division Committees & Coordinating Groups

The Fluids Engineering Division has three coordinating groups and three technical committees. The functions of the coordinating groups and committees are related to the areas of fluids engineering reflected by their names.

Participation in the committees and coordinating groups is on a voluntary basis. Each committee and group meets twice each year-once at the FED Summer Meeting and once at the International Mechanical Engineers Congress & Exposition. Schedules for these meetings can be found on the web site just prior to each meeting-or at the registration desk at the site hotel. If ASME members wish to participate in a committee or coordinating group proceedings-they are free to do so; this is one of the many benefits of ASME membership in the Fluids Engineering Division.

Specific activities and functions of each of the committees and coordinating group activities are described in the following paragraphs. Usually the contact point is the Chair-however if difficulty in contacting the Chair arises, please contact Richard R. Schultz (208 526-9508; FAX: 208 528-0628; srr@inel.gov).

Coordinating Group on Fluid Measurements

The Coordinating Group on Fluid Measurements (CGFM) is the center for experimental measurements within the FED. The CGFM membership includes specialists in instrumentation, experimental techniques, design of experiments, measurement accuracy and uncertainty, and data acquisition and analysis. The group membership is composed of individuals from each of the Technical Committees as the topic of fluid measurements permeates all of the FED. As a Coordinating Group, the group charter is to work closely with the technical committees and to provide updates on the latest developments in fluid measurements through programs at technical meetings and other technology transfer activities.

During recent FED meetings the CGFM has cooperated on such recurring symposia and forums as Laser Anemometry, Experimental and Numerical Flow Visualization, Measuring and Metering Unsteady Flows, and Measurement Techniques in Multiphase Flows. In addition, the group hosts technical sessions including recurring programs in Fluid Measurements and Instrumentation and Fluid Measurement Uncertainty Applications. Along with these recurring themes, the group organizes or participates in upcoming topical sessions on Cryogenic Fluid Flows, Liquid Crystal Thermometry, Flow Measurements in Opaque Multiphase Fluids, and Experimental Needs for CFD Development and Verification.

For more information, visit the CGFM web site at http:/www.asme.org/divisions/fed/cgfm.html. The CGFM encourages all who are interested in planning, organizing, or participating in technical sessions in the general area of fluid measurements to become involved. For more information on the CGFM, or to receive future meeting notifications and minutes, feel free to contact the Chair: Dr. Joel T. Park of the U.S. Navy Large Cavitation Channel (901) 947-3117 or the Vice-Chair: Professor Jim Liburdy of Oregon State University (541) 737-7017.

Coordinating Group on Computational Fluid Dynamics

The Coordinating Group on Computational Fluid Dynamics (CGCFD) is a body dedicated to providing a means for researchers and applications scientists and engineers to disseminate CFD related information through symposia and forums at ASME meetings. In addition, CGCFD encourages acceptance of CFD by industry and provides for networking of CFD professionals worldwide. At the FED summer meetings the CGCFD organizes symposia and forums centered on topics such as finite element applications in fluid mechanics, high speed jet flows, flows in manufacturing processes, numerical developments in CFD, advances in free surface and interface flows, and bifurcation, instability, and hysteresis in fluid flow. The Group is also frequently sponsors tutorials on CFD-specific topics and panel sessions.

The Chair of the Group is Prof. Urmila Ghia, Department Head of Mechanical, Industrial and Nuclear Engineering at the University of Cincinnati. The Vice-Chair of the Group is Prof. Peter Raad, Professor of Mechanical Engineering at the Southern Methodist University in Dallas, Texas, and Associate Dean of the School of Engineering and Applied Science. If questions arise, please contact Prof. Urmila Ghia at 513-556-4612, urmila.ghia@uc.edu; or Prof. Peter Raad at (214) 768-3043; peter@seas.smu.edu.

Coordinating Group on Industrial Technology

The Coordinating Group on Industrial Technology (CGIT) was formed in 1999. The primary function of CGIT is to develop symposia, forums, and panels that specifically address technology issues important to industry and to work with the other technical committees and coordinating groups of FED. Although the CGIT does not have a long tradition in the FED it is responsible for one of the most interesting ares in fluids engineering: the application of fundamental principles to solve industrial problems.

If questions arise, please contact the Chair: Dr. Mano Dhaubhadel of the Case Co. (630-887-2009) or the Vice Chair: John Navickas of the Boeing Co. (714-372-1432).

Fluid Applications and Systems Technical Committee

The Fluid Applications & Systems Technical Committee (FASTC) programs focus on providing state-of-the-art knowledge to support mature, developing, and emerging applications in the general field of fluid mechanics. FASTC does this by providing an interface between designers, developers, and researchers. FASTC activities also include programs designed to enhance learning and discussion. Examples include panel discussions, tutorials, and clinics earmarked for promoting participation from industry. FASTC is organized into three subcommittees: Fluid Transients, Fluid Machinery, and Emerging and Developing Applications.

In the past FASTC has sponsored symposia and forums (sometimes in conjunction with other committees or coordinating groups) such as Fluid Measurements and Instrumentation, Industrial and Environmental Applications of Fluid Mechanics, Fluid Machinery Forum, Industrial Applications of Swirling Flow, and Computational Methods for Analysis of Fluid Machinery. FASTC also offers a Pumping Machinery Symposium on a regular basis.

If you would like to participate in FASTC activities, or if you have any questions or suggestions, please contact the Chair: Dr. Adiel Guinzburg of Boeing (818-586-7622) or the Vice Chair: Dr. Awatef Hamed of the University of Cincinnati (513) 556-3553.. You can also obtain additional information by visiting the FASTC Web Site: http://www.asme.org/divisions/def/fastc

Fluid Mechanics Technical Committee (FMTC)

The Fluid Mechanics Technical Committee (FMTC) serves as the focal point within ASME for technical activities in fundamental fluid mechanics. The main activity of FMTC is to organize symposia and forums related to all aspects of basic fluid mechanics. The committee strives to provide timely technical information to the ASME membership through well-organized technical sessions and to foster dialog among the membership. Currently, there is a major emphasis on the development of rolling three-year plans for symposia and forum development. Typically, the symposia and forms are planned and organized through one of our four sub-committees. The FMTC sub-committees are External Flows; Internal Flows; Unconventional/ Emerging Topics; and Unsteady Flows. Members are welcome to participate and to help organize the technical sessions and other activities of the FMTC.

General information about FMTC including planned symposia / forums as well as the past minutes of business meetings can be found on our web page (http://www.asme.org/divisions/fed/FMTC). For further information you may contact either the FMTC Chair: Professor Ganesh Raman of the Illinois Institute of Technology (312) 567-3554 or the Vice-Chair: Dr. George Papadopoulos of Dantec Measurement Technology (201) 512-0037, x 121.

Multiphase Flow Technical Committee

The Multiphase Flow Technical Committee (MPFTC) organizes symposia and forums related to gas-liquid and fluid-solid flows in odd years and computational and experimental methods in even years at the FED Summer Meetings. Generally, multiphase flow is a huge technological activity that transcends what has been the traditional scope of past meetings. Serving our membership therefore calls for new initiatives that go beyond these traditional boundaries. The ICMECE offers a great opportunity for the organization of joint activities with other divisions which also have a strong multiphase flow component such as Heat Transfer, Manufacturing, Acoustics, and others. The planning of joint symposia with these divisions is well under way.

If you have questions or suggestions please contact the Chair: Dr. Steven L. Ceccio of the University of Michigan (313) 936-0433 or the Vice Chair: Professor Gretar Trygvasson of the Worcester Polytechnic Institute (508) 831-5759.

2001 Fluids Engineering Division

Summer Meeting
May 29–June 1, 2001
New Orleans, Louisiana
Sheraton New Orleans Hotel
www.asme.org/conf/fed01

The Fluids Engineering Division Summer Meeting will take place at the Sheraton New Orleans, May 29 through June 1, 2001. Full conference information is available on the conference web site at **http://www.asme.org/conf/fed01**. There will be approximately 80 technical sessions and all of the FED committees will hold their meetings there. There will also be a number of special events, including Fluids Engineering Clinics, in which conference attendees are invited to meet with technical experts and get their advice (see article by Demetri Telionis), tutorials, and plenary lectures. There will be three tutorials, on 1) "Pumping Machinery" by Adiel Guinzburg, The Boeing Company, 2) "Modern Applications of Experimental Uncertainty Analysis" by Hugh W. Coleman, University of Alabama in Huntsville and W. Glenn Steele, Mississippi State University, and 3) "Code Verification and Validation" by Frederick Stern, University of Iowa. The plenary lectures will be held each morning, and will be on 1) "The U. S. R&D Enterprise - Status and Future Trends" by Norm Abramson, Southwest Research Institute (retired), 2) "Improving the Acceptability of Flow Measurements" by George Mattingly, NIST, 3) "Pump Technology - Are We Making Progress?" by S. Ghopalakrishnan, Flowserve Corporation, and 4) "Agile Engineering for Advanced Turbomachinery Products" David Japikse, Concepts NREC, The FED awards luncheon will be held Wednesday, May 30. Our luncheon speaker is Marvin Perrett of the National D-Day Museum in New Orleans, who will give a talk entitled "Return to Normandy."

This will be an exciting time for fluid dynamics in New Orleans. The International Conference on Multiphase Flows (ICMF-2001) will also take place in New Orleans, LA from May 27 through June 1 at the Marriott Hotel, directly across the street from the ASME Fluids Engineering Division Meeting. All full-paid registrants of the ASME-FED Meeting will be entitled to attend all technical events of the ICMF-2001. They will also receive, at no extra cost, a program and the CD-ROM proceedings of the ICMF-2001. The following week the ASME Turbo Expo and International Joint Power Generation Conference and Exposition will be held at the Ernest Morial Convention Center. There are also several fluids-related ASME Continuing Education courses that will be held in New Orleans around the FED conference, including Waterhammer and Fluid Structure Interaction in Piping Systems, May 31-June 1, and The Gas Turbine: Principles and Applications, June 4-5. For more information on these courses, visit www.asme.org/pro_dev.

Clinics at the FED Summer Meeting

We are organizing again a clinic session at our summer meeting. This activity provides the opportunity for practicing engineers to interact directly with experts in specific fields.The clinics will be again part of the broader program "Industry Exchange Program". Here is how this activity will be structured:

On an afternoon during the meeting, a large room will be set aside for the clinics. Each clinic is given a table and is identified with a sign. Each clinic is concerned with a specific topic of importance to industry. At each table sit the "clinicians". These are experts on the topic, from government, academia or industry, willing to offer their advice and short consulting during the clinic, free of charge. Participants of the meeting are welcome to visit a clinic and present their problem. This leads either to discussions among "clinicians" and visitors or specific working sessions on a one-to-one basis. These discussions can be carried on during the clinic, but partnerships thus established can lead to formal consulting work or other agreements that can be negotiated later.

This year we organized the following clinics at the FED Summer Meeting in New Orleans:

- "Consultation on the Application of CFD Codes - Application of CFD to Real-World Problems" Chris Freitas and Mano Dhaubhadel
- "Surface Pressure and Temperature Methods, Five- and Seven-hole probes. Pressure Transducers, Scanners,etc."Timothy Wei and Demetri Telionis
- "Internal Flow Velocity and Turbulence Measurements - Laser-Doppler Velocimetry (LDV),Volkan Otungen
- "Particle-Image Velocimetry (PIV)" Pavlos Vlachos
- "Multi-Phase Flow - Cavitation, Particulate Flow, Modeling" Upendra Rohatgi and Joe Katz

Honors & Awards

2000 Fluids Engineering Award

The winner of the 2000 Fluids Engineering Award is Dr. Fazle Hussain of University of Houston. Dr. Hussain was selected for this award for his outstanding contributions to fluid mechanics research and teaching. Dr. Hussain has served on several editorial boards for such leading journals as *The Physics of Fluids*, *Journal of Fluids Engineering*, *Turbulence in Liquids and Experimental Thermal and Fluid Science*. He has also served on numerous national and international review panels and scientific committees and organized a number of workshops and conferences. He is a Fellow of APS and ASME and an Associate Fellow of AIAA. Currently, he is Distinguished Professor at University of Houston and the Director of the Institute of Fluid Dynamics and Turbulence, which comprises of the Aerodynamics and Turbulence Laboratory and the Vortex Technology Center.

Dr. Hussain obtained his BSME from Bangladesh University in 1963 and became a lecturer the same year. In 1965, he received the highly competitive Fulbright Scholarship to pursue graduate studies in mechanical engineering at Stanford University. His Ph.D. thesis won him the Stanford's Eckhart Prize for excellence in 1969. After serving for 18 moths as Assistant Professor at Johns Hopkins University, he joined University of Houston as an Assistant Professor in Mechanical Engineering. He became a Professor in 1976. Dr. Hussain has supervised numerous graduate and undergraduate research projects and dissertations. He has received continuing support for his research through grants from federal agencies and has published extensively in fluids engineering journals and presented numerous seminars and invited and keynote lectures at major national and international conferences. In 1985, the University of Houston recognized his outstanding achievements by awarding him the first Research Excellence Award and promoting him to Distinguished University Professor. In 1989, he became the Cullen Distinguished Professor. During his career, he has received numerous other awards and recognitions including the ASME Freeman Scholar award in 1984. He was also awarded the 1998 Fluid Dynamics Prize by the American Physical Society.

Robert T. Knapp Award

This award is given to the authors of the best paper presented to the Fluids Engineering Division dealing with analytical, numerical and laboratory research. The year 2000 award is received by Mr. Scott Coppen and Dr. Chris Rogers for the paper "Correlating Particle Dynamics with Local Fluid Structures in Turbulent Flows". The paper was presented at the 3rd ASME/JSME Joint Fluids Engineering Conference in San Francisco, CA, in July 1999. The paper presented advances to the understanding of particle-laden turbulent flows and the effects of large mass loading on diffusivity.

Scott Coppen received his BSME degree from University of Massachusetts at Dartmouth. He received his MSME degree from Tufts University in 1998 and is currently working toward the Ph.D. degree. Dr. Rogers received all his degrees at Stanford University. He is currently at Tufts University.

Lewis F. Moody Award

The Lewis F. Moody Award is given to the authors of the best paper presented to the Fluids Engineering Division dealing with a topic useful to mechanical engineering practice. The year 2000 award is received by Dr. Michael Amitay and Dr. Ari Glezer for their paper "Aerodynamic Flow Control of a Thick Airfoil Using Synthetic Jet Actuators". The paper was presented at the 3rd ASME/JSME Joint Fluids Engineering Conference in San Francisco, CA, in July 1999. The paper presents the development and practical application of a MEMs-based synthetic actuator for flow control.

Dr. Michael Amitay has been a Research Engineer at Georgia Tech Research Institute since 1996. Dr. Amitay received his BSc., MSc. and D.Sc. in Aerospace Engineering from the Technion, Israel Institute of Technology in 1987, 1990 and 1994, respectively. Dr. Ari Gleser is Professor of Fluid Mechanics in the George W. Woodruff School of Mechanical Engineering at Georgia Institute of Technology. He received his MS. And Ph.D. degrees from California Institute of Technology in 1975 and 1981, respectively.

International Mechanical Engineering Congress and Exposition

November 11-16 2001
New York Hilton Hotel & Towers and
Sheraton New York Hotel & Towers
New York, New York

The forums presented at the upcoming meeting will be:

Fluid Transients
Lead Organizer:
Dr. Asif H. Arastu, Bechtel Corporation, 50 Beale St., 50/7/C51, San Francisco, CA 94105-1895, Ph: 415-768-2247, Fx: 415-768-3328, aarastu@bechtel.com
Other Organizer:
Dr. Fred J. Moody, 827 Larkspur Lane, Murphys, CA 95247, Ph: 209-728-1616, fmoody@goldrush.com

Parallel Computing Methods
Lead Organizer:
Dr. Christopher J. Freitas, Computational Mechanics, Southwest Research Inst., 6220 Culebra Road, San Antonio, TX 78238-5166, Ph: 210-522-2317, Fx: 210-522-3042, cfreitas@swri.edu
Other Organizer:
Dr. E. Hyptopoulos, Silicon Graphics Computer Systems, 39001 West Twelve Mile Road, Farmington Hills, MI 48331, Ph: 810-576-4036, Fx: 810-848-5600, ehytopou@detroit.sgi.com

Industrial Compressors
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Dr. Jinkook Lee, Argo-Tech Corp., 23555 Euclid Ave., Cleveland, OH 44117-1795, Ph: 216-692-5084, Fx: 216-692-6639, leej@argo-tech.com
Prof. Abraham Engeda, Mechanical Engr. Dept., Michigan State University, A231 Engineering Bldg., East Lansing, MI 48824-1226, Ph: 517-432-1834, Fx: 517-353-1750, engeda@me.msu.edu
Other Organizer:
Prof. Ali Ogut, Dept. of Mech. Engr., Rochester Institute of Technology, 76 Lomb Memorial Rochester, NY 14623, Ph: 716-475-2542, Fx: 716-475-7710, adoeme@rit.edu

Global Measurements: Techniques and Industrial Applications
Lead Organizers:
Dr. George Papadououlos, Dantec Measurement Technology Inc., 777 Corporate Drive, Mahawah, N.J. 07430, Tel: 201-512-0037 Ext 121, Fax: 201-512-0120; george.papadououlos@dantecmt.com
Dr. Khaled J. Hammad, Dantec Measurement Technology Inc.,Tel: 201-512-0037 ext 114, khaled.hammad@dantecmt.com
Other Organizers:
Dr. Gregory J. Fiechtner, Innovative Scientific Solutions Inc., 2766 Indian Ripple Road, Dayton, OH 45440-3638, Tel: 937-255-8373; Fax: 937-255-3139; gjfiech@appl.wpafb.af.mil
Dr. Ganesh Raman, Mechanical Materials and Aerospace Engineering Dept., Illinois Institute of Technology, 32nd Street, Chicago, Il 60616, Tel: 312-567-3554, raman@iit.edu

Forum on Bifurcation, Instability and Hysteresis in Fluid Flow
Lead Organizers:
Dr. George Papadououlos, Dantec Measurement Technology Inc., 777 Corporate Drive, Mahawah, N.J. 07430, Tel: 201-512-0037 Ext 121, Fax: 201-512-0120; george.papadououlos@dantecmt.com
Dr. Francine Battaglia, Dept. of Mechanical Engineering, Iowa State University, 3027 H.M. Black Engineering Building, Ames, IA 50011-2161; Tel: 515-294-2085, Fax: 515-294-3261, francine@iastate.edu
Other Organizers:
Dr. Dimitris Drikakis, Queen Mary and Westfield College, Engineering Dept., University of London, Miles End Road, London E1 ns, UK; Tel: 44-171-975-5194, Fax: 44-181-983-1007; d.drikakis@qmw.ac.uk
Prof. Tom Mulilin, Dept of Physics and Astronomy, University of Manchaster, Manchaster M13 9PL, UK; Tel: 44-161-275-4100; Tom.mullin@man.ac.uk

Multiphase Flows in Biomedical Applications and Processes
Lead Organizer:
Prof. J.K.R. Kadambi, Mechanical and Aerospace Engineering Dept., Case Western Reserve University, Cleveland, Ohio 44106; Tel: 216-368-6439, Fax: 216-368-6445; jxk11@po.cwru.edu
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Prof. Steven Ceccio, Mechanical Engineering and applied Mechanics, University of Michigan, Ann Arbor, M.I. 48109-21212, tel: 734-936-0433, fax: 734-764-4256, Ceccio@engin.umich.edu

Multiphase Flow Industrial Applications
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Fluid Measurements Uncertainty Applications
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Open Forum on Computational Techniques in Micro and Nano Scale Flow and Heat Transfer
Lead Organizer:
Prof. S.P. Vanka, University of Illinois at Urbana-Champaign, Dept. of Mechanical and Industrial Engineering, 1206 W Green Street, Urbana, IL 61801
Other Organizers:
Prof. J.Y. Murthy, Dept. of Mech Engg, Carnegi Mellon University, Pittsburgh, Pa,
Prof. K.N. Ghia, Dept. of Aerospace Engg, University of Cincinnati, Cincinnati, OH 45221-0070
Prof. F. Forster, University of Washington, Dept. of Mech Engg, Campus Box 352600, Seattle, WA 98195-2600, Forster@u.washington.edu

University-Industry Collaborative Research in Multiphase Flow
Lead Organizer:
Dr. M.C. Roco, National Science Foundation, Engineering. Directorate, Suite 5254201 Wilson Blvd., Arlington, VA 22230, Ph. 703-306-1371, Fx. 703-306-0319, mroco@nsf.gov

General Papers
Lead Organizer:
Prof. John Baker, U. Alabama - Birmingham, Dept. of Matl's and ME, 1150 Tenth Avenue South, Birmingham, Alabama 35294-4461 Ph: 205-934-7508, Fx: 205-934-8485, jbaker@eng.uab.edu
Other Organizer:
Prof. Frank White, Dept. of Mech. Engr. Univ. Rhode Island, 92 Upper College RdKingston, RI 02881-0805 Ph: 401-874-2542 Fx: 401-874-2355, whitef@egr.uri.edu