出國報告（出國類別：參加國際會議）

參加2011年美國、日本、韓國機械工程協會聯合流體工程研討會

服務機關：海軍軍官學校
姓名職稱：葉豐賓 教授
派赴國家：日本
出國期間：100 年7月23日至100年7月30日
報告日期：100 年9月8日

摘要

面對全球的氣候變遷、有限的能源資源和經濟危機，需要全球的產官學合作，以找到適當解的解決方法。基於此共識上，三個社團決定於 2011 年 7 月 24 日至 2011 年 7 月 29 日在日本靜岡縣濱淞市的 ACT City Congress Center 舉辦 2011 年美國、日本、韓國機械工程協會聯合流體工程研討會(AJK2011-FED)。此次研討會的大會主席由東京大學的 Yoichiro MATSUMOTO 教授所擔任。其中開幕式特別邀請 Dr. Ayao Tsuge, Mr. Jayden Harman and Dr. Kil-Choo Moon 擔任演講者，講題主題分別爲 "Enhancement of Capability for Science & Technology Driven Innovation ", "Biomimicry: Nature's Operating Instructions for Energy Efficient Fluid Handling" and "Research and Development Strategies for Fluid Mechanics for the Future"。

研討會內容包括(一)Symposium：計算流體力學之發展、 DNS,LES和混合RANS / LES方法、計算流體力學的應用、多相流數值分析方法、流體機械-葉輪之數值模擬、機械泵、流體動力、流-固偶合作用、液-固流動、氣液兩相流、單相和多相流之非侵入性測量、天然氣粒子流、流體操作和控制、材料加工和製造之傳輸現象、航空太空之流體應用、流體力學的基本問題和觀點、綠色能源在能源轉換時之轉換現象、核子工程應用及其系統之計算流體力學、仿生流體力學、沉浸邊界方法之發展與應用、混合之傳輸現象、流體機械、計算流體力學驗證與確認、紊流流動之問題、工業與環境應用之流體力學。(二)Forum：流體量測、多相流之發展、空蝕和多相流、流體工程教育、微流體。(三)Technical Flash：工業上複雜之流體現象、計算流體力學套裝軟體、環境問題和新能源、非侵入式之流體測量應用等。藉由參加多場學術演講與壁報觀摩，吸收新知，瞭解國際間目前在流體基礎科學、應用工程、流體工程傳輸現象之研究趨勢與方向，獲益良多。

目次

參加會議目的

從全球的角度來看，世界正面臨著巨大的挑戰，其中包括全球氣候的變遷、有限的能源資源和經濟危機。而這些問題是廣泛且極爲複雜，需要全球的產官學合作，以找到適當的解決方法。在此基礎上，三個社團決定在日本靜岡縣濱淞市的 ACT City Congress Center 舉辦 2011 年美國、日本、韓國機械工程協會聯合流體工程研討會(AJK2011-FED)。此會議提供了來自世界各地的研究人員、科學家和從業者交流信息的一個論壇，不僅提出新的信息，並討論未來重點領域的流體傳輸現象及方向。研討會內容包括：計算流體力學之發展、 DNS,LES 和混合 RANS / LES 方法、計算流體力學的應用、多相流數値分析方法、流體機械-葉輪之數值模擬、機械泵、流體動力、流-固偶合作用、液-固流動、氣液兩相流、單相和多相流之非侵入性測量、天然氣粒子流、流體操作和控制、材料加工和製造之傳輸現象、航空太空之流體應用、流體力學的基本問題和觀點、綠色能源在能源轉換時之轉換現象、核子工程應用及其系統之計算流體力學、仿生流體力學、沉浸邊界方法之發展與應用、混合之傳輸現象、流體機械、計算流體力學驗證與確認、紊流流動之問題、工業與環境應用之流體力學、流體量測、多相流之發展、空蝕和多相流、流體工程教育、微流體、工業上複雜之流體現象、計算流體力學套裝軟體、環境問題和新能源、非侵入式之流體測量應用等。藉由參加多場學術演講與壁報觀摩，吸收新知，瞭解國際間目前在流體基礎科學、應用工程、流體工程傳輸現象之研究趨勢與方向。

參加會議過程

2011 年美國、日本、韓國機械工程協會聯合流體工程研討會(AJK2011-FED)於 2011 年 7 月 24 日至 2011 年 7 月 29 日於日本靜岡縣濱淞市的 ACT City Congress Center 舉行。該研討會吸引數百位來自世界各地之專家學者與會，共有約六百篇的論

文發表與四十篇的壁報論文展示。內容範圍從基礎的流體科學到應用流體工程系統、流體機械、計算流體力學、流體工程之傳輸現象並包含再生能源與環境保護議題。

主辦單位將此國際會議之論文發表與壁報論文展示均設立於濱淞市的 ACT City Congress Center 。此研討會的大會主席爲東京大學的 Yoichiro MATSUMOTO 教授。AJK2011 - FED 從 ASME、JSME 和 KSME 共邀請了六位傑出的演講者擔任講座。前三位演講者擔任開幕式時的講座，所討論的主要議題是產官學界之間對於先進流體工程設計、創新及可持續發展的環境和能源所應扮演的角色。他們分別是 Dr. Ayao Tsuge, President of Shibaura Institute of Technology, 講題爲 "Enhancement of Capability for Science & Technology Driven Innovation "，Mr. Jayden Harman, President and CEO of PAX Scientific, 講題爲"Biomimicry: Nature's Operating Instructions for Energy Efficient Fluid Handling" 和 Dr. Kil-Choo Moon, President of Korea Institute of Science and Technology, 講題爲"Research and Development Strategies for Fluid Mechanics for the Future"。另外三位演講者是 Prof. James Riley from ASME, 講題爲"Some Fluid Dynamical Issues in the Siting of Turbines for Tidal Energy" ，Prof. Jung Yul Yoo from KSME, 講題爲"Solid-Liquid Two-Phase Flows in Microfluidics"，和 Prof. Kozo Fujii from JSME, 講題爲"Toward Second-Era of Computational Fluid Dynamics -From the Observation from the Studies in Aerospace-"。 此次大會之論文發表共分爲 10 個場地同時舉行，區分 Symposium, Forum and Technical Flash 等方向，其中 Symposium 分爲 26 大主題，Forum 分爲 5 大主題，Technical Flash 分爲 4 大主題，每大主題又區分爲數個場次，在不同時段於不同場地進行發表。共 110 場次，發表 596 篇論文。

Symposium

S01: 16th Symposium on Algorithmic Developments in CFD(12)

S02: 6th Symposium on DNS, LES and Hybrid RANS/LES Methods(9)

S03: 11th Symposium on Applications in Computational Fluid Dynamics(39)

S04: 11th International Symposium on Numerical Methods for Multiphase Flow(20)

S05: 12th International Symposium on Advances in Numerical Modeling for Turbomachinery Flow Optimization(12)

S06: 7th International Symposium on Pumping Machinery(61)

S07: 11th International Symposium on Fluid Power(20)

S08: 12th Symposium on Fluid-Structure Interaction and Flow-Induced Noise in Industrial Applications(24)

S09: 12th International Symposium on Liquid-Solid Flows(17)

S10: 12th International Symposium on Gas-Liquid Two-Phase Flows(27)

S11: Symposium on Non-Invasive Measurements in Single and Multiphase Flows(25)

S12: 13th International Symposium on Gas-Particle Flows(15)

S13: 6th Symposium on Flow Manipulation and Active Control: Theory, Experiments and Implementation(13)

S14: 10th Symposium Transport Phenomena in Materials Processing and Manufacturing Processes(15)

S15: 5th International Symposium on Flow Applications in Aerospace(19)

S16: 9th Symposium on Fundamental Issues and Perspectives in Fluid Mechanics(22)

S17: 4th Symposium on Transport Phenomena in Energy Conversion From Clean and Sustainable Resources(11)

S18: Computational Fluid Dynamics of Nuclear Engineering Applications and Systems(6)

S19: 2nd Symposium on Bio-Inspired Fluid Mechanics(11)

S20: Symposium on Development and Applications of Immersed Boundary Methods(9)

S21: 4th Symposium on the Transport Phenomena in Mixing(13)

S22: 23rd Symposium on Fluid Machinery(32)

S23: Symposium on Issues and Perspectives in Ground Vehicle Flows(24)

S24: 3rd Symposium on CFD Verification and Validation(4)

S25: 2nd International Symposium on Turbulent Flows: Issues and Perspectives(18)

S26: 18th Symposium on Industrial and Environmental Applications of Fluid Mechanics(5)

Forum

F01: Forum on Fluid Measurements and Instrumentation(18)

F02: Open Forum on Multiphase Flows: Work in Progress(13)

F03: 46th Cavitation and Multiphase Flow Forum(17)

F04: Advances in Fluids Engineering Education(2)

F06: Microfluidics Summer Forum(23)

Technical Flash

T01: Technical Flash on Complicated Phenomena in Industry(7)

T02: Technical Flash on Progress in CFD Software(20)

T03: Technical Flash on Environmental Problems and New Energies(8)

T04: Technical Flash on Applications of Nonintrusive Fluid Measurement(5)

與會心得

本會議為國際研究流體力學傳輸現象極為重要之研討會，會議中共發表近六百篇論文。藉由參加多場學術演講與壁報論文觀摩，吸收新知，瞭解國際間目前在流體基礎科學、應用工程、熱流體工程傳輸現象之研究趨勢與方向，獲益良多。

建議

應多鼓勵大專院校之師生多參與類似之國際學術活動，以增進學校於國際之能見度。

附錄

Numerical simulation of plasma actuator

F. B. Yeh

Department of Marine Mechanical Engineering
ROC Naval Academy, Taiwan, R. O. C.

ABSTRACT

Isothermal surface plasma can be generated using a dielectric barrier discharge to induce fluid flow and operate as an actuator for flow control. In the present work, we present a two-dimensional simulation of dielectric barrier discharge (DBD) using the finite element based plasma module of COMSOL numerical software. The plasma and fluid flow are treated as a two-fluid system coupled by body force. The body force can be calculated using the ion density and the electric field. The two-species hydrodynamic plasma model coupled Poisson equation and Navier–Stokes equation are solved to predict flow structure. Parameters related to the electrode operating variable such as voltage, frequency and geometric arrangements are varied to investigate the characteristics of the plasma and induced flow.

KINETIC MODEL AND ANALYSIS

In this work, the schematic of an asymmetric single dielectric barrier plasma actuator is shown in Fig.1.

Simplified form of plasma model

The species number densities and the momentum transport are solved using plasma-fluid equations along with the Poisson equation for the potential. The continuity and momentum equations of ions are

$$\frac{\partial n_i}{\partial t} + \nabla \cdot (n_i v_i) = n_e S_{ie} - r n_i n_e \tag{1}$$

$$n_i \mu_i E - \nabla(n_i D_i) = n_i v_i \tag{2}$$

The continuity and momentum equations of electrons are

$$\frac{\partial n_e}{\partial t} + \nabla \cdot (n_e v_e) = n_e S_{ie} - r n_i n_e \tag{3}$$

$$n_e \mu_e E - \nabla(n_e D_e) = n_e v_e \tag{4}$$

The electric field E is obtained using the solution of the Poisson equation, given by

$$\nabla \cdot (\varepsilon_d E) = \frac{e(n_i - n_e)}{\varepsilon_0} \tag{5}$$

Body force approach for plasma-fluid flow coupling

Shyy et al. proposed to devise a source term is to account for the plasma effect in the form of the body force in the momentum equation. The primary collision loss between the heavier ions and the neutral particles is considered. To neglect the diffusion flux, the loss due to collision balanced by the Lorentz force acting on the charged ions is derived. Consequently this collision loss can be viewed as the instantaneous local body force acting on the neutral fluid particles and can be modeled as a source term in the Navier-Stokes equation.

Governing equations of the fluid flow

In the present article we look at low Reynolds number flows in both the laminar and transitional turbulent regimes. We can decouple treatment between the plasma and the fluid. The numerical model consists of the continuity and momentum equations for a steady incompressible viscous flow.

$$\frac{\partial \vec{A}}{\partial t} + \frac{\partial \vec{B}}{\partial x} + \frac{\partial \vec{C}}{\partial y} = \vec{D} \tag{6}$$

$$\vec{A} = \begin{bmatrix} \rho \\ \rho u \\ \rho v \end{bmatrix} \tag{7}$$

$$\vec{B} = \begin{bmatrix} \rho u \\ \rho u^2 + p - \tau_{xx} \\ \rho uv - \tau_{xy} \end{bmatrix} \tag{8}$$

$$\vec{C} = \begin{bmatrix} \rho v \\ \rho uv - \tau_{xy} \\ \rho v^2 + p - \tau_{yy} \end{bmatrix} \tag{9}$$

$$\vec{D} = \begin{bmatrix} 0 \\ F_x \\ F_y \end{bmatrix} \tag{10}$$

F_x and F_y are the body force components, which carry the effect of the plasma discharge on the fluid flow. A source of constant average body force in time is considered and defined

$$F_x = E_x \sum_k q_k n_k \tag{11}$$

$$F_y = E_y \sum_k q_k n_k \tag{12}$$

REFERENCES

Siemens W. Plasma discharges. Poggendroffs Ann Phys Chem 1857;102:66.

Kogelschatz U, Eliasson B, Egli W. From ozone generators to flat television screens: history and future potential of dielectric-barrier discharges. Pure Appl Chem 1999;71-10:1819 – 28.

Roth JR, Sherman DM, Wilkinson SP. Boundary layer flow control with a one atmosphere uniform glow discharge. In: 36th AIAA aeropsace sciences meeting, Reno NV, January 12 – 15, AIAA paper 98-0328.

Roth JR. Industrial plasma engineering: Vol. I—Principles. Bristol: IOP; 1995.

Roth JR. Electrohydrodynamically induced airflow in a one atmosphere uniform glow discharge surface plasma. In: Proceedings of the 25th IEEE international conference on plasma science, Raleigh, NC paper 6P-67, 1998. p. 291.

Kanazawa S, Kogoma M, Moriwaki T, Okazaki S. Stable glow plasma at atmospheric pressure. Phys D Appl Phys 1988;21: 838.

Massines F, Ben Gadri R, Rabehi A, Decomps Ph, Segur P, Mayoux Ch. Experimental and theoretical study of a glow discharge at atmospheric pressure controlled by dielectric barrier. J Appl Phys 1998;83-6:2950 – 7.

Corke TC, Post ML. Overview of plasma flow control: concepts, optimization and applications. In: 43rd Aerospace sciences meeting and exhibit, Reno, NV, AIAA paper 2005-0563.

Roy S, Gaitonde DV. Modeling surface discharge effects of atmospheric RF on gas flow control. In: 43rd AIAA aerospace sciences meeting, Reno NV, AIAA paper 2005-0160.

Roy S, Gaitonde DV. Multidimensional collisional dielectric barrier discharge for flow separation control at atmospheric pressures. In: 35th AIAA fluid dynamics conference, Toronto, Canada, AIAA paper 2005-4631.

Singh KP, Roy S. Simulation of an asymmetric single dielectric barrier plasma actuator. J App Phys 2005;98:083303.

Kumar H, Roy S. Multidimenisonal hydrodynamic plasma-wall model for collisional plasma discharges with and without magneticfield effects. Phys Plasmas 2005;12:093508.

Shyy W, Jayaraman B, Anderson A. Modeling of glow-discharge induced flow dynamics. J Appl Phys 2002;92-11:6434 – 43.

Jayaraman B, Thakur S, Shyy W. Modeling of dielectric barrier discharge and resulting fluid dynamics. In: 44th Aerospace sciences meeting & exhibit, Reno, NV, January 9 – 12, AIAA paper 2006- 0686.

Jayaraman B, Cho YC, Shyy W. Modeling of dielectric barrier discharge and resulting fluid dynamics. In: 38th Plasmadynamics and lasers conference, Miami, FL, June 25 – 28, AIAA paper 2007- 4531.

Jayaraman B, Shyy W, Thakur S. Modeling of fluid dynamics and heat transfer induced by dielectric barrier plasma actuator. J Heat Trans 2007;129(4):517 – 25.

FIGURES

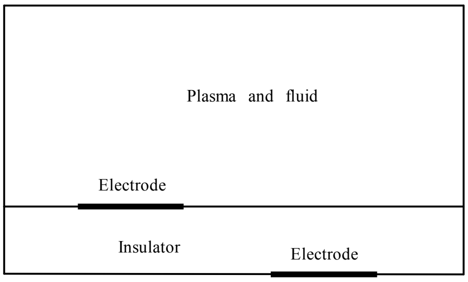

Fig.1 Schematic of an asymmetric single dielectric barrier plasma actuator.