Topology optimization of manifold fluid channel design with mass flowrate control

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ABSTRACT

Topology optimization for flow problems has garnered considerable interest recently across various applications, including enhancing the efficiency of energy systems through optimized energy, momentum, and heat transfer. Conventional design methods typically rely on parametric models, which may limit the discovery of novel conceptual designs and their interconnections. In contrast, topology optimization offers a pathway to generate novel configurations of these components, aiming to enhance their efficiencies and ensure target flow distribution—an essential factor in optimizing the performance of energy system components. In this study, a topology optimization framework is proposed to address the multi-outlet problem with mass flowrate control. The objective function is normalized power dissipation, which can also be considered as pressure drop. The control includes both volume control and mass flowrate control. The mass flowrate control for each outlet is defined with lower and upper limits, set at 1% below and above the target mass flow rate, respectively. For cases with Reynolds numbers of 100, 300, and 500, the mass flowrate control across six outlets achieves an average control accuracy of 99.02%, which is within a reasonable range for the control target. The proposed method shows potential for application in heat exchanger systems to improve energy efficiency.

Keywords: Topology optimization; Mass flowrate control; Lagrange multiplier.

ACKNOWLEDGEMENT

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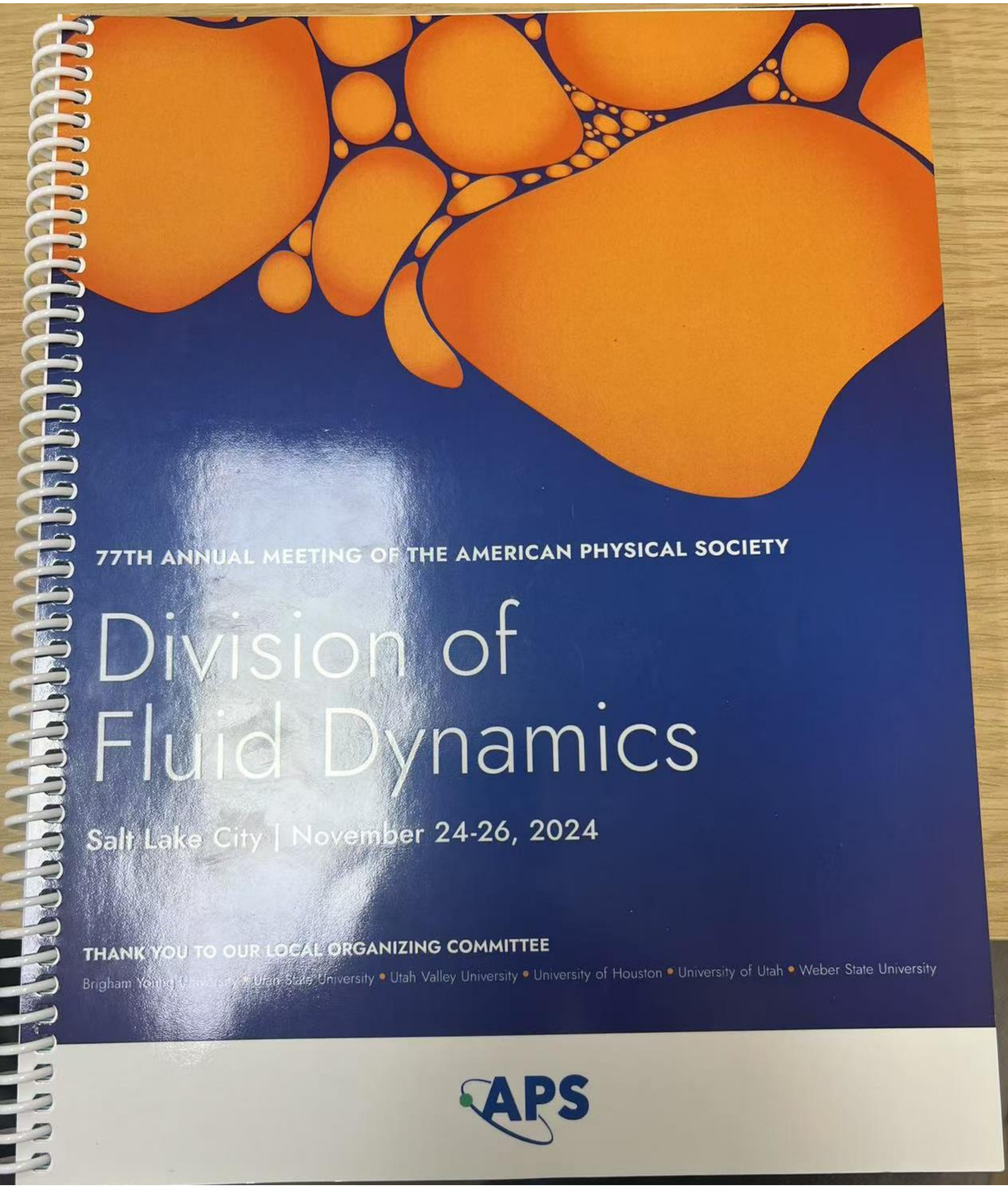

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Tuesday Morning, November 26, 2024

Session	8:00 AM	8:13 AM	8:26 AM	8:39 AM	8:52 AM	9:05 AM
X09. Drops: General II Room: Ballroom I Chair: M. Mezhericher, Princeton U.	**X09.01** Ancient Raindrops and the Paradox of a Faint Young Sun *M. Mezhericher, H. Stone*	**X09.02** Non-resonant effects in pilot-wave hydrodynamics *B. Primkulov, D. Evans, J. Been, J. Bush*	**X09.03** Memory-enhanced diffusivity in stochastically forced walking droplets *F. Sazunic Ljubetic, A. Blitstein, K. Newhall, P. Saenz*	**X09.04** Collective dynamics of freely interacting walking droplets *I. Stevenson, J. Clampett, M. Labousse, R. Rosales, P. Saenz*	**X09.05** Experimental Investigation of Droplet Spreading on a Stationary and Moving Solid Surface *M. Sanchez, M. Yamazaki, D. Kurihara, H. Sakaue*	**X09.06** Aging Effect of Contact Line Dynamics on Monolayer Surfaces *Y. LI, Y. Lee, J. Shen, T. MOUTERDE, J. Shiomi*
X10. Drops: Impact on Solid Surface, Including Fibers Room: Ballroom J Chair: S. Shin, St. Univ of NY - Buffalo	**X10.01** Modeling Droplet Spreading Dynamics using Physics-Informed Neural Networks *E. Kianiharchegani, M. Dreisbach, A. Stroh, G. Karniadakis*	**X10.02** Energy dissipation and maximum solidification-limited spreading of impacting drops *P. Yan, C. Mccormack, H. Kavehpour*	**X10.03** Unusual impact behavior of molten lithium microdrops *J. Kim, H. Lee, D. Park, Y. Lee, H. Kim*	**X10.04** When Do Microdroplets Bounce? *J. Mclauchlan, A. Souslov, A. Squires*	**X10.05** Numerical Investigation of a High-speed Droplet Impact onto a Rigid Surface *E. Burrell, E. Johnsen*	**X10.06** Rebound of a droplet impacting a non-wetting rigid surface *E. Aguero Vera, E. Aguero Vera, K. Kuehr, C. Galeano-Rios, R. Cimpeanu, J. Barotta, E. Silver, C. Gabbard, D. Harris*
X11. Nonlinear Dynamics: Model Reduction Room: 155 A Chair: O. T. Schmidt, UC San Diego	**X11.01** Discovery of Nonlinear Flow Physics Using Optimal Modal Momentum and Energy Budget Analysis *O. Schmidt, B. Yeung, T. Chu*	**X11.02** Building dynamical stability into data-driven quadratic reduced-order models *M. Peng, A. Kaptanoglu, C. Hansen, J. Stevens-Haas, K. Manohar, S. Brunton*	**X11.03** Data-driven stability analysis of chaotic systems in latent spaces *E. zalp, L. Magri*	**X11.04** Proper latent decomposition (PLD) *D. Kelshaw, L. Magri*	**X11.05** Mori-Zwanzig Mode Decomposition: Transient Flows *M. Woodward, Y. Tian, A. Gabbana, Y. Lin, D. Livescu*	**X11.06** Nonlinear reduced-order modelling in frequency domain for turbulent flows *X. Li, D. Lasagna*
X12. Low-Order Modeling and Machine Learning in Fluid Dynamics: Methods VI Room: 155 B Chair: F. Sotiropoulos, Virginia Commonwealth U.	**X12.01** Hybrid Auto-Encoder with SVD-like Convergence *N. Somasekharan, S. Pan*	**X12.02** Reduced Representations of Turbulent Rayleigh-Bnard Flows via Autoencoders *M. Vinograd, M. Vinograd, P. Clark Di Leoni*	**X12.03** Data-driven linear analysis of turbulent flows via nonlinearity-subtracted dynamic mode decomposition *B. Herrmann, K. Cao, C. Gonzalez, S. Brunton, B. McKeon*	**X12.04** Dynamic mode decomposition for self-similar dynamics *K. Chen, J. Page*	**X12.05** A meshless method to compute the POD and its variants from scattered data *I. Tirelli, M. Mendez, A. Ianiro, S. Discetti*	**X12.06** Non-Gaussian Variational Data Assimilation Embedded Reduced-Order Modeling Methods Through Statistical Error Transformations *M. Khan, C. Huang*
X13. CFD: Applications I Room: 155 C Chair: R. McDermott, National Inst. of Standards and Technology (NIST)	**X13.01** Two-Dimensional Modeling and Simulation of Nonlinear Isothermal Gradient Elution Chromatography with Radial Concentration Gradients *M. Abid*	**X13.02** Abstract Withdrawn	**X13.03** Assessing relevant roughness scales for accurate predictions of iced airfoils in both glaze and rime conditions *T. Bellosta, A. Donizetti, F. Zabaleta, B. Bornhoft, S. Jain, S. Bose, A. Guardone*	**X13.04** Efficient Inflow Generation for Wind Loading Predictions for Low-Rise Buildings *M. Ciarlatani, C. Gorle*	**X13.05** Topology optimization of manifold fluid channel design with mass flowrate control *K. Gao, H. Kang, M. Wang, H. Leon-Rodriguez, C. Mao*	**X13.06** Numerical study of the flow and thermal characteristics in an internal permanent magnet synchronous motor *J. Kwon, G. Son*
X14. Microfluidic Flow Applications II Room: 155 D Chair: A. Nourhani, U. Akron	**X14.01** A Comparative Study of Wicking Flow on Micro-Engineered Surfaces Using Micro-PTV and Phase-Field Lattice Boltzmann Method *Z. KHAN, A. Bohara, N. Raventhiran, A. Fakhari, Y. Li*	**X14.02** Navigation of a three-link microswimmer via deep reinforcement learning *Y. Lai, S. Heydari, O. Pak, Y. Man*	**X14.03** Understanding the non-isothermal fluid dynamics of the annular flow boiling regime inside a microchannel *D. Mysore Basavaraja, M. Magnini, O. Matar*	**X14.04** Ion-specific Activation and Inactivation of Ion Transport in 2D Subnanoporous Membrane *Y. Noh, A. Smolyanitsky*	**X14.05** A comparative numerical evaluation of the cooling performance in microchannel heat sinks for low and high Reynolds number laminar flows. *L. Ramaube, M. Louis, H. Stone, S. Smith*	**X14.06** Isobaric molecular simulation of boiling *A. Saha, O. Matar*
X15. Low-Order Modeling and Machine Learning in Fluid Dynamics: Turbulence Modeling I Room: 155 E Chair: L. Ma, Arizona St. U.	**X15.01** Epistemic Uncertainty Quantification of Deep Neural-Network Based Turbulence Closures *C. Grogan, S. Dutta, M. Tano, S. Dhulipala, I. Gutowska*	**X15.02** Improving Predicted Statistics of Velocity Gradient Closures using Parameterized Lagrangian Deformation Models *C. Hyett, M. Woodward, Y. Tian, M. Stepanov, C. Fryer, D. Livescu, M. Chertkov*	**X15.03** Neural Network-Based Closure Model of the Ensemble-Averaging Dynamics of Turbulent Puffs in Transitional Pipe Flow *Y. Shuai, C. Rowley*	**X15.04** RANN: A Neural RANS Closure Model for Physics-Informed Machine Learning on General Geometries *M. Uffenheimer, L. Rigazio, E. Meiburg*	**X15.05** Subgrid Stress Modeling with Data Driven Structured State Space Sequence Models *A. Wu, S. Lele*	**X15.06** The multiscale-based data-driven subgrid-scale model with physics constraints for enhanced prediction of unresolved scales in turbulent flow *B. Jalaali, K. Okabayashi*
X16. CFD: IBM Room: 155 F Chair: B. Lewis, BYU - Idaho	**X16.01** A systematic computational study of debris cluster impact on the performance of utility-scale marine hydrokinetic turbines under mobile bed conditions *M. Aksen, H. Seyedzadeh, M. Anjiraki, J. Craig, K. Flora, C. Santoni, F. Sotiropoulos, A. Khosronejad*	**X16.02** Improving the conditioning of the immersed boundary projection method *D. Beckers, S. Balasubramanian, A. Goza, H. Bae*	**X16.03** High Reynolds number immersed boundary method for turbulent flows *S. Cai*	**X16.04** A high order sharp immersed method for the simulation of moving bodies interacting with fluid flows *X. Ji, W. van Rees*	**X16.05** Simulation of multiple propellers using a GPU-optimized overset grid-based Immersed Boundary method. *D. Kumar, S. Roy*	**X16.06** Boundary conditions for reaction-diffusion systems in an Immersed Boundary framework *O. Lewis, R. Guy, B. Leathers*