Proceedings of the 15th International Green Energy Conference
IGEC2023-361~371 (invited)
July 10-13, 2023, Glasgow, UK

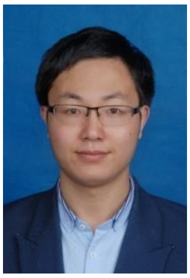
Special Session: Advances in Thermoacoustic Technology

Session Description:

Thermoacoustics is an interdisciplinary science that encompasses the fields of thermodynamics and acoustics. It is a fascinating subject that studies the thermoacoustic effect arising from the interaction between a compressible fluid and a porous material. In thermoacoustic engines, an appreciable temperature gradient is imposed along the porous material that induces spontaneous acoustic oscillations while in thermoacoustic refrigerators, the acoustic waves are utilized to produce a hydrodynamic heat pumping effect along the porous material.

This Special Session is dedicated to the latest advances in thermoacoustic technology. It provides a unique platform to present state-of-the-art research findings in thermoacoustic devices (including thermoacoustic engines, thermoacoustic electric generators, thermoacoustic refrigerators/cryocoolers, etc.) and aims to promote innovative solutions associated with the practical applications of thermoacoustic technology. Contributions that investigate thermoacoustics-related issues in sound and vibration, thermal science, or materials/energy science, using theoretical, numerical, or experimental methodologies, from component to system levels, are welcomed.

Session Organizer(s):



Dr. Geng Chen
National Engineering Research Center of Turbo-Generator Vibration, School of Energy and Environment, Southeast University, Nanjing 210096, China
chengeng@seu.edu.cn

Dr. Jingyuan Xu
Mechanical and Electrical Engineering Division, Karlsruhe Institute of Technology, 76131 Karlsruhe, Germany
jingyuan.xu@kit.edu

Session Contents:

Topic 1: Efficient energy harvesting with multi-stage thermoacoustic engines: A comparative analysis based on linear and CFD modelling

Topic 2: Stability analysis of thermoacoustic engine with unconventional stacks

Topic 3: Solid-state Thermoacoustics: A New Paradigm of Thermoacoustic Research

Topic 4: Improving Energy Efficiency and low heating temperature of a thermoacoustic cooler driven by a thermoacoustic engine with varying length of regenerators

Topic 5: Recent advances and future directions of thermoacoustic energy conversion systems

Topic 6: The principles and ways of achieving high performance on heat-driven thermoacoustic refrigerator/heat pump

Topic 7: On the transition from R&D to a product

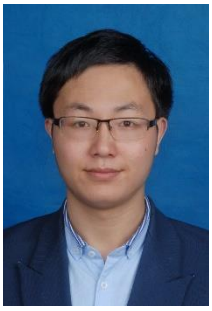
Topic 8: Thermoacoustic conversion with wall mass transfer

Topic 9: Investigation of thermoacoustic Stirling engine loaded with a liquid column

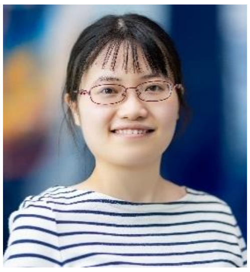
Topic 10: Revisit Thermoacoustic Mixture Separation

Topic 11: Synchronization of Taconis oscillations under external forcing: results of CFD and low-order modeling

Organizers' Biography:



Dr. Geng Chen is currently a lecturer (assistant professor) and postgraduate supervisor in the School of Energy and Environment, Southeast University (SEU), China. He received his PhD degree from the University of Auckland, New Zealand in March 2021 and joined SEU in May 2021. He was a visiting scholar at James Watt School of Engineering, University of Glasgow, UK. His research mainly focuses on thermoacoustic engines, power generators, and refrigerators. He is the Double-Innovation Doctor of Jiangsu Province and was nominated for the Vice-Chancellor's Prize of best doctoral thesis by University of Auckland. So far, he has published more than 30 research articles in the international authoritative journals such as Renew. Sustain. Energy Rev., J. Sound Vib. and Int. J. Heat Mass Transf. He has been invited to the serve as the reviewer for more than 30 international journals and the academic/review/guest editor for a few international journals.



Dr. Jingyuan Xu is currently a research scientist in Karlsruhe Institute of Technology (KIT), Germany. She received her Ph.D. degree from Technical Institute of Physics and Chemistry of the Chinese Academy of Sciences (CAS) in 2018 (CAS Outstanding Doctoral Dissertation Award, Beijing Outstanding Postgraduate Award, Wu Zhonghua Outstanding Postgraduate Award, etc). After her PhD, she worked as a Postdoctoral Research Fellow at University of Cambridge and then as a Research Associate at Imperial College London before joining KIT. Her research focuses on sustainable energy technologies based on thermoacoustics for cooling, heating and power generation. She has published over 40 peer-reviewed papers and granted 16 patents. She has been awarded Carl von Linde Award Young Researcher Award by International Institute of Refrigeration, Gustav and Ingrid Klipping Award by International Cryogenic Engineering Committee.

Proceedings of the 15th International Green Energy Conference
IGEC2023-361 (invited)
July 10-13, 2023, Glasgow, UK

Topic 1: Efficient energy harvesting with multi-stage thermoacoustic engines: A comparative analysis based on linear and CFD modelling

Armando Di Meglio
University of Naples "Parthenope", Department of Engineering, Centro Direzionale Napoli 80143 - Italy
armando.dimeglio001@studenti.uniparthenope.it

Abstract

Thermoacoustic engines are promising systems that can convert heat into electricity using acoustic power. This technology is considered green and sustainable when waste heat, such as exhaust gas from internal combustion engines, is used as an energy input. The thermoacoustic core, in which the energy conversion takes place, consists of a regenerator sandwiched between hot and cold heat exchangers. Increasing the number of thermoacoustic cores can enhance the efficiency and acoustic power of the device. This article presents the design of a multi-stage travelling wave engine using linear acoustic theory and DeltaEC software, followed by a systematic comparison with results obtained from nonlinear simulations using OpenFOAM, an open-source Computational Fluid Dynamics (CFD) environment. The linear approach allows for a large parametric design, optimizing the variables of interest and fixing the constraints, while the nonlinear approach captures phenomena that are inherently neglected by the previous approach, such as minor losses, despite the much higher computational cost. The designs proposed in this approach strongly considers some technical constraints for manufacturing the Heat Exchangers and the coupling between the thermoacoustic core and an audio speaker as electric transducer The linear results show that for a resistive load of 10 Ω and a hot temperature fixed at 530 K the device is able to produce approximately 300 W with a Carnot efficiency equal to 25%. The CFD results, conducted in absence of acoustic load, show that pressure and velocity distributions are qualitatively in agreement with linear results. However, the DeltaEC results tend to overestimate their amplitude because all nonlinear effects are intrinsically neglected.

Short bio:

Mr. Armando Di Meglio is currently a Ph.D. candidate at Parthenope University of Naples. He completed his Bachelor's degree in Mechanical Engineering at Federico II University, followed by a Master's degree in Mechanical Engineering for Energy and Environment. His thesis focused on the numerical and experimental evaluation of aerodynamic noise in the automotive field.

During his Ph.D., Armando has further developed his mathematical and physical background with a specific focus on numerical methods and Computational Fluid Dynamics (CFD) simulation for thermoacoustic energy systems. He also spent six months as a visiting Ph.D. student at Swansea University, enhancing his international experience and expertise in the field.

Mr. Armando D Meglio has published nine indexed articles on Scopus, demonstrating his dedication to contributing to academic research in his specialized field.

Proceedings of the 15th International Green Energy Conference
IGEC2023-362 (invited)
July 10-13, 2023, Glasgow, UK

Topic 2: Stability analysis of thermoacoustic engine with unconventional stacks

Elio Di Giulio
Department of Industrial Engineering, University of Naples "Federico II", Naples 80125, Italy
elio.digiulio@unina.it

Abstract

Thermoacoustic engines are devices that convert thermal energy into acoustic power based on the thermoacoustic effect. This effect is produced when a temperature gradient is applied to a porous material (named *stack*). The stability analysis enables the assessment of the thermal and geometrical parameters required for the device to sustain the thermoacoustic phenomenon. Generally, uniform cross-sectional stacks are employed, and analytical formulations of their behaviours are available in the literature. This research work deals with the stability analyses and onset conditions of thermoacoustic engines (TEA) with unconventional stacks, such as 3D-oriented pin array. Their characterization can be made through semi-phenomenological models, such as the one provided by Johnson-Champoux-Allard-Lafarge. The overall behaviour of a thermoacoustic system can be predicted through the Transfer Matrix Method, which represents a fundamental tool to provide stability analyses and onset conditions. In the experimental approach, the two-microphones' technique is employed to evaluate the surface impedance of the overall thermoacoustic device. The results are compared with the theoretical predictions through the Transfer Matrix approach. Once the analytical modelling has been validated, preliminary stability analyses on the use of 3D-oriented pin array stacks have been conducted. The results lead to conclude that utilizing such porous materials as thermoacoustic stacks offers interesting opportunities to improve the performance and the working conditions (i.e. lower hot temperature) of thermoacoustic devices.

Short bio:

Elio Di Giulio completed his doctoral degree in Acoustics at University of Naples "Federico II", defending his thesis titled "Thermo-fluid Dynamic Properties of Porous Materials for Energy Conversion" in 2023. In 2022, he was a visiting scholar at the University Gustave Eiffel in Paris. He is actually a research fellow at the University of Naples "Federico II". Elio's primary focus lies in the numerical and experimental characterization of porous materials under oscillating flow for acoustic and energy applications. Since his master's thesis in 2019, Elio has been actively involved in the field of thermoacoustics, specifically studying heat transfer in oscillating flow. His work revolves around the characterization and analysis of porous materials for various energy conversion processes. With his expertise in numerical simulations and experimental investigations, Elio aims to contribute to the advancement of both acoustic and energy-related technologies.

Proceedings of the 15th International Green Energy Conference
IGEC2023-363 (invited)
July 10-13, 2023, Glasgow, UK

Topic 3: Solid-state Thermoacoustics: A New Paradigm of Thermoacoustic Research

Haitian Hao, Carlo Scalo, Fabio Semperlotti
School of Mechanical Engineering, Purdue University, West Lafayette IN 47907
ht19930702@gmail.com

Abstract

Thermoacoustics phenomenon refers to the coupled process of thermodynamics and acoustic resonance in which heat and mechanical power (in the form of sound wave) can be converted into each other. The exploration of thermoacoustic physics has led to the development of various engineering devices, such as thermoacoustic heat engines. To date, all the existing thermoacoustic devices rely on fluids (e.g., pressurized air, Helium) as the working medium for energy conversion. However, our study for the first time shows the theoretical evidence that the fascinating phenomenon of thermoacoustic energy conversion takes place in solid media as well. Solid-state thermoacoustics share some commonalities with the well understood fluid-based thermoacoustic phenomenon, such as its existence in both standing wave and traveling wave. Important distinctions, which originate from the difference between solids and gases in material properties, are also observed. For example, solids can sustain flexural waves which do not exist in fluids, leading to a unique thermoacoustic mode associated with the flexural motion of solids. Solids have the potential to be engineered with their properties tuned to be thermoacoustically beneficial. The idea of thermoacoustic instability based on engineering materials is also discussed in this study. The exploration of solid-state thermoacoustics unveils a new paradigm of thermoacoustic research, opening the opportunity of designing highly efficient, compact and robust thermoacoustic devices.

Short bio:

Dr. Haitian Hao obtained his Ph.D. degree from Purdue University in 2021. He is now an Acoustic Test Engineer in industry. Dr. Hao's research is focused on thermoacoustic instability, acoustic metamaterials and thermoacoustic metamaterials. He has published 1 US patent and 15 journal and conference papers. He received the Leo Beranek Medal for Excellence in Noise Control Studies, and Adaptive Structures and Material Systems Best Paper Award in Structures and Structural Dynamics.

Proceedings of the 15th International Green Energy Conference
IGEC2023-364 (invited)
July 10-13, 2023, Glasgow, UK

Topic 4: Improving Energy Efficiency and low heating temperature of a thermoacoustic cooler driven by a thermoacoustic engine with varying length of regenerators

Irna Farikhah
Department of Mechanical Engineering, Universitas PGRI Semarang, Indonesia
irnafarikhah@upgris.ac.id

Abstract

Thermal pollution caused by industrial waste heat has harmful effects on the environment. Moreover, the scarcity of renewable energy is another global issue. Thermoacoustic technology such as thermoacoustic engine is one of the solutions that can be used to recover this waste heat for an alternative energy by converting it into acoustic energy. On the other hand, another environmental issues such as depletion ozone layer and global warming due to the conventional cooling system are also need to be tackled. Thermoacoustic cooler is an alternative one which is safe for environment. The acoustic energy generated by the engine could be transferred for cooling processes in the cooler. The present study focuses on the design to improve efficiency of the whole system and low-onset heating temperature of the engine. Numerical investigations were conducted by varying engine and cooler regenerators length simultaneously (from 0.11 to 0.32). The results showed the highest total efficiency of the whole system (16%) were achieved when the engine and cooler regenerators length are 0.21 and 0.15, respectively. It was found that the upper limit value of the engine and cooler are 61 % and 37 %, respectively and the tube efficiency is 69 %. Moreover, the heating temperature is 230 ℃.

Short bio:

Irna Farikhah is currently an Assistant Professor in Mechanical Engineering, Universitas PGRI Semarang, Indonesia. She hold a Ph.D degree from Tokyo University of Agriculture and Technology Japan majoring in System Engineering (Thermoacoustic). Moreover, she published some articles in some International Journals and Proceedings from International Conferences in Singapore, Tokyo and London. In 2019, she got scholarship from Turkish government as a research fellowship in Department of Mechanical Engineering, Celal Bayar University, Turkey. In 2020, she has appointed as a visiting research fellow at the Universitas Malaysia Perlis (UniMAP). She also a member of World Society of Sustainable Energy Technologies (WSSET).

Proceedings of the 15th International Green Energy Conference
IGEC2023-365 (invited)
July 10-13, 2023, Glasgow, UK

Topic 5: Recent advances and future directions of thermoacoustic energy conversion systems

Kai Wang

Institute of Refrigeration and Cryogenics, Zhejiang University, Hangzhou 310027, China

kaiwang19@zju.edu.cn

Abstract

Recovering waste heat from natural or industrial processes for power generation or refrigeration is attractive for improving energy efficiency and lowering energy costs for the society and industries. Thermoacoustic energy conversion systems show promising application prospects in small-scale distributed solar power generation, waste heat recovery, cryogenic refrigeration, heating provision, etc, due to their good reliability, cost-effectiveness and potentially high efficiency. This talk starts with a general introduction of thermoacoustic energy convertion technologies. Recent advances on the modeling, design and development of thermoacoustic energy conversion systems will be reviewed. In particular, the design, development and system integration of a LNG power generation system based on a gas turbine and a novel thermoacoustic Stirling power generator capable of recovering both waste heat and LNG cold energy will be introduced. Thoughts on promising future directions of thermoacoustic energy conversion will be discussed at the end.

Short bio:

Dr. Kai Wang is a Research Professor in the Institute of Refrigeration and Cryogenics at Zhejiang University. He received his B.Eng. degree in Energy and Environment Systems Engineering and Ph.D. degree in Power Engineering and Engineering Thermophysics from Zhejiang University in 2009 and 2014, respectively. Before joining Zhejiang University, he worked as a postdoctoral researcher in the Clean Energy Processes (CEP) Laboratory at Imperial College London during 2018-2019 and in the Energy Research Institute at Nanyang Technological University during 2014-2017. He is the Managing Editor for the journal Applied Thermal Engineering since 2019.

His research interests focus primarily on high-performance energy technologies, components and systems for energy saving and carbon-emission reduction, including liquid-hydrogen production, storage and refuelling, organic Rankine cycles, thermoacoustic power generators/coolers, Stirling engines, co-/trigeneration systems and solar thermal technologies. He is the recipient of the Sadi Carnot Award from the International Institute of Refrigeration (IIR), one of the IIR Scientific Awards for young researchers working on thermodynamics. To date (January 2023), he has published 1 book, 2 book chapters, more than 60 peer-reviewed journal papers and owns more than 10 patents.

Proceedings of the 15th International Green Energy Conference
IGEC2023-366 (invited)
July 10-13, 2023, Glasgow, UK

Topic 6: The principles and ways of achieving high performance on heat-driven thermoacoustic refrigerator/heat pump

Kaiqi Luo

Building Energy Research Center, Tsinghua University, Beijing, China

lkq0624@mail.tsinghua.edu.cn

Abstract

Thermoacoutic technology gradually becomes a promising energy solution for low-carbon refrigeration or heat supply. In particular, the heat-driven type thermoacoustic refrigerator/heat pump shows its great advantages of environmental-friendly working medium (helium, nitrogen, etc.), utilization of varieties of heat sources (solar energy, waste heat, fuel gas, etc.) and simple configuration. Based on the previous research on the impedence phase matching between the thermoacoustic engine and thermoaocutic refrigerator/heat pump, a direct-coupling configuration was proposed and several heat-driven thermoacoustic refrigerators with direct-coupling unit have been developed. However, the performance of the direct-coupling unit cannot be enhanced under a higher heating temperature, mainly attributed to the dismatch between the acoustic power generation in the engine subunit and the acoustic power consumption in the refrigerator/heat pump subunit. In order to achieve a high-efficiency heat-driven thermoacoustic refrigerator/heat pump, novel configurations of heat-driven thermoacoustic cooling/heating system are proposed. To reveal the advantages of the novel configurations, comparative investigations are conducted, including the coefficient of performance, exergy efficiency, acoustic impedance distribution and so on. The simulated results obviously indicate that the novel configurations' energy efficiencies can be effectively improved with the increasing of heating temperature, compared with the direct-coupling unit. This work aims at exploring high-efficiency utilizations of various heat sources in the field of cooling/heating.

Short bio:

Dr. Kaiqi Luo obtained her Ph.D degree from Technical Institute of Physics and Chemistry, University of Chinese Academy of Sciences in 2021. Since graduation, she joined Building Energy Research Center of Tsinghua University as a postdoctoral researcher. Dr. Luo's research is focused on thermoacoustic energy conversion technology, especially including the investigations on the heat-driven or eletric-driven thermoacoustic Stirling refrigerators/heat pumps.

Proceedings of the 15th International Green Energy Conference
IGEC2023-367 (invited)
July 10-13, 2023, Glasgow, UK

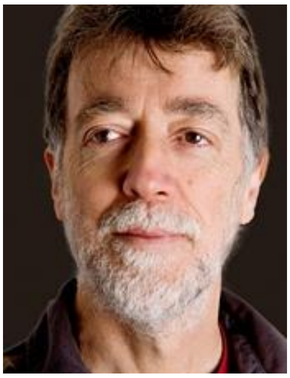
Topic 7: On the transition from R&D to a product

Kees de Blok
Aster Thermoacoustics, Netherlands
kees@aster-thermoacoustics.com

Abstract: Since the eighties of last century thermoacoustic energy conversion hold the promise of a robust, save and sustainable technology for utilizing solar or waste heat in industrial cooling applications on any scale at any temperature. An ever-expanding thermoacoustic community has been conducting theoretical and experimental research and working on applications to exploit and commercialize the specific benefits of thermoacoustics and Aster and SoundEnergy were one of them. The question of today is, why hardly any techno-economic feasible application or product have been realized so far?

In an attempt to give an answer, results and practical issues while working with thermoacoustic devices will be addressed based on my experience by Aster and Soundenergy. Part of the answer will be about the product (THEAC-25) and how and where it is installed and in operation. The other part being key to future successful thermoacoustic applications or products deals with the environmental factors and demarcations that play an important role in this. This includes technical, financial and legal- and safety regulations such as amongst others, the European Pressure Equipment Directive. We need remind ourselves that thermoacoustics is no longer a scientific challenge but an engineering and economic one and by this kind of issues we are more related to and limited by the outside world than we are used for in our R&D field.

Short bio:



Kees (C.M.) de Blok (July 6th 1954, married, a son and two daughters) was educated as an engineer in electronics and was employed from august of 1971 until 2000 at the R&D institute of the Dutch telecom operator KPN. Since 1978 he was one of the pioneers developing measuring and installation techniques for the first experimental (1980) and operational (1982) optical fibre links in the Netherlands and gained a lot practical and theoretical experience in the field of lasers, optics and microwave technology. Currently he is active in further R&D in optimizing the modelling and performance of thermoacoustic systems in general, and is active and involved in introduction of this innovative conversion technology into new applications or into applications which are not feasible today by using conventional technologies for technical, economic or environmental reasons (e.g. f-gasses). since May 2022 he start working again but now at Bekaert Combustion Technology B.V. in the Netherlands on understanding and modelling thermoacoustic oscillations in hydrogen and other flames.

Proceedings of the 15th International Green Energy Conference
IGEC2023-368 (invited)
July 10-13, 2023, Glasgow, UK

Topic 8: Thermoacoustic conversion with wall mass transfer

Rui Yang

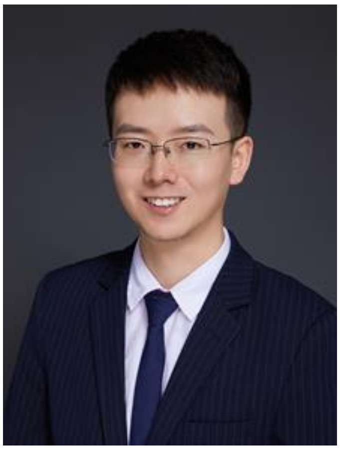
CAS Key Laboratory of Cryogenic, Technical Institute of Physics and Chemistry, Chinese Academy of Sciences, Beijing 100190, China

yangrui@mail.ipc.ac.cn

Abstract

Thermoacoustic engines attract much attention for their lack of moving parts and relatively benign environmental impact. After more than four decades of research, the room for further improving thermoacoustic systems through traditional pathways, such as improving the acoustics, is becoming increasingly narrow. A promising approach to break through the current limitations is the thermoacoustic conversion with wall mass transfer. This refers to a way of enhancing the thermoacoustic conversion through incorporating the acoustic-induced mass transfer, such as phase change, adsorption and absorption between the wall and the fluid, into the conventional thermoacoustic cycle. Theoretically, it has been predicted that the output power of the engine (or the cooling power of the refrigerator) can be increased by up to one order of magnitude and its efficiency up to 40% of Carnot limit as compared to those of the conventional thermoacoustic systems, when the temperature difference is low. This indicates the promising potential of the wall-mass-transfer thermoacoustic systems in efficient energy conversion with low temperature difference, covering applications like waste heat recovery and low temperature lift heat pumping. So far, the proof-of-concept implementations of these novel thermoacoustic engines and refrigerators have been realized. To further develop high-performance engineering prototypes, proper stacks(or regenerators) for efficient and stable mass transfer and high-performance heat exchangers are urgently needed.

Short bio:



Dr. Rui Yang is an associate professor at Technical Institute of Physics and Chemistry, Chinese Academy of Sciences. He received his Ph.D. degree in Refrigeration and Cryogenic Engineering from Zhejiang University in 2017. Before joining Technical Institute of Physics and Chemistry, he worked as a postdoctoral researcher in Technion-Israel Insitute of Technology in Israel during 2018-2021. He has published over 30 papers in leading journals. His research topics include thermoacoustic engine, thermoacoustic refrigerator and transport phemomena in oscillatory flow.

Proceedings of the 15th International Green Energy Conference
IGEC2023-369 (invited)
July 10-13, 2023, Glasgow, UK

Topic 9: Investigation of thermoacoustic Stirling engine loaded with a liquid column

Shu-Han HSU

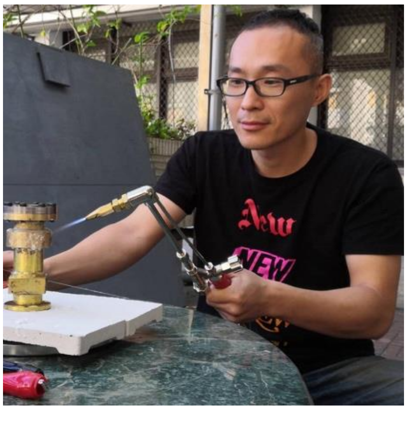
Department of Mechanical Engineering, National Taipei University of Technology, Taipei, Taiwan

bookhsu@ntut.edu.tw

Abstract

In this study, we discuss the conditions of spontaneous oscillations of the thermoacoustic Stirling engine loading with a liquid column of water. The thermoacoustic engine exhibits remarkable simplicity with no solid moving parts. As an external heat engine, it is a highly promising technology for sustainable energy because of the usage of environmentally friendly working gas, low manufacturing cost, and maintenance-free. Several mechanical loads have been reported for extracting the acoustic power generated by thermoacoustic engines, including linear alternators, piezoelectric diaphragms, and flywheels with solid pistons. To eliminate the usage of any solid moving parts, this study investigates using a vertically positioned U tube partially filled with liquid water as the acoustic load for the engine. Via a T-junction tube, the liquid column in the U tube is attached to the looped tube engine contained with a differentially heated regenerator, with one end opened to atmospheric air. By loading the engine with the oscillating liquid column, it is possible to further apply on generating electricity through the magnetohydrodynamic transducer or water pumping. Also, the water column can be considered as a replacement for the branch tube in a typical thermoacoustic Stirling engine consisting of looped and branch tubes with a pure gas column. This results in a significant decrease in the engine's spontaneous oscillation angular frequency due to the greater mass of the liquid compared to the gas. From a qualitative standpoint, a lower natural angular frequency enables the use of the regenerator with larger pores, which benefits reducing viscous losses while maintaining good thermal contact. This study calculates the onset temperature of the engine using the linear thermoacoustic theory framework with impedance matching at the gas-liquid interface and then verifies it through experiments.

Short bio:



Dr. HSU Shu Han received his Ph.D. in Engineering from Tohoku University in Sendai, Japan in 2017. He has been working as an assistant professor at National Taipei University of Technology in Taipei, Taiwan since 2018. His research interests focus on studying thermoacoustic engines/refrigerators using both theoretical and experimental approaches, as well as exploring applications of thermoacoustic devices.

Proceedings of the 15th International Green Energy Conference
IGEC2023-370 (invited)
July 10-13, 2023, Glasgow, UK

Topic 10: Revisit Thermoacoustic Mixture Separation

Yuki Ueda

Department of Mechanical System Engineering, Tokyo University of Agriculture and Technology, Tokyo, Japan

uedayuki@cc.tuat.ac.jp

Abstract

It is well known that an acoustic wave can cause an energy conversion between thermal energy and acoustical energy and can transport those energies. In addition to these energy conversion and transport, the Los Alamos National Laboratory's group discovered that an acoustic wave can separate mixtured gases; when an acoustic wave propagates in a narrow tube filled with a mixture gas, one component of the mixture flows toward one side of the tube and the other component flows toward the other side. This phenomenon is very interesting, and can be related to wet-wall thermoacoustic effects that have been actively investigated. Nevertheless, there are only a few researches about the acoustically-caused mixture separation, except a series of studies by the LANL's group. In this study, we have experimentally revisited their researches and confirmed the phenomenon. In the presentation, the mechanism of the thermoacoustic mixture separation will be reviewed and the experimentally-founded physical parameters affecting the thermoacoustic mixture separation will be discussed.

Short bio:

Dr. Yuki Ueda obtained his Ph.D. degree from Nagoya University in 2005. He was a postdoctoral fellow at The University of Tokyo from 2005 to 2006. He joined the Tokyo University of Agriculture and Technology as an associate professor in 2006, and then, he has been a professor since 2019. Dr. Ueda's research is focused on thermoacoustics, which can be related to sustainable energy technologies, renewable/waste energy utilization, and advanced heat pump. He has obtained some patents and published around 50 journal papers. Note that the picture was taken 17 years ago.

Proceedings of the 15th International Green Energy Conference
IGEC2023-371 (invited)
July 10-13, 2023, Glasgow, UK

Topic 11: Synchronization of Taconis oscillations under external forcing: results of CFD and low-order modeling

Peng Yang

Key Laboratory of Thermo-Fluid Science and Engineering of MOE, School of Energy and Power Engineering, Xi'an Jiaotong University, Xi'an, Shaanxi 710049, P R China

yp2019@mail.xjtu.edu.cn

Abstract

It has been proved in combustion and hydrodynamic systems that external forcing can effectively control self-excited oscillations, while there are few works on active control of Taconis oscillation. In this paper, we force the cryogenic helium tube system by a piston, to study the synchronization process of forced Taconis oscillation with different forcing frequencies and intensities. Comparing the results with the forced van der Pol oscillator – a universal low-order model, we find their qualitative conformities and quantitative differences. Conformities are reflected in: the two systems both experience the torus-birth and torus-death bifurcation toward synchronization; and both systems exhibit the full range of phase dynamics. These indicate the similarity between Taconis oscillation and other self-excited oscillatory systems, and provide the theoretical basis for applying self-excited oscillation control methods from other fields to Taconis oscillation. Differences are reflected in: the forced Taconis oscillation appears amplitude reduction only when the forcing frequency is greater than the self-excited frequency, and the minimum amplitude comes before synchronization. Accordingly, an active control strategy to suppress Taconis oscillation is given. Moreover, based on the Rayleigh criterion, we have explained why the "beats" appears, and revealed that both the pressure and heat absorption rate respond to the external forcing.

Short bio:

Dr. Peng Yang is an associate professor at Xi'an Jiaotong Univeristy. He received his Ph.D. degree for power engineering and engineering thermophysics from Xi'an Jiaotong Univeristy in 2018. He was a visiting scholar at University of Illinois at Urbana-Champaign in 2016-2017. He joined Xi'an Jiaotong Univeristy as an assistant professor in 2019. Dr. Yang's research is focused on enhancement for heat and mass transfer, analysis and optimization for thermodynamic cycles, including thermoacoustic/Stirling/refrigeration/heat pump technologies, advanced system thermal management. He has published a over 30 SCI journal papers and owned some patents. He also serves as an reviewer for some famous international journals.