Mechanical Motion Rectifier: A High Efficiency and Reliable WEC Power Takeoff

Abstract: The power takeoff (PTO), the machinery to convert the mechanical energy into electricity, is widely considered as the single most important element in wave energy technology, and underlies many of the failures to date (A. Falcao 2010). The state-of-the-art ocean wave energy technology either uses direct-drive power takeoffs with linear electromagnetic generator or indirect-drive power takeoffs using intermediate fluid. The direct drives are simple and reliable but require heavy and bulk permanent magnets; the indirect drives are more compact but suffer from serious shortcomings on the complexity, reliability, and efficiency. Revolutionary power takeoff is urgently needed in order to realize the vast electricity potential from the ocean waves. This talk will present the design, modelling, lab test, wave tank test, and ocean trial of a "mechanical motion rectifier" based power takeoff, which converts the irregular oscillatory wave motion into regular unidirectional rotation of the generator. Lab tests show that up to 80% mechanical energy conversion efficiency was achieved with reduced force in the PTO motion system. The rotation inertia and two-body system design can further increase the power output in a large frequency range. Wave tank test and ocean trail also validated the high efficiency and reliability. The mechanical motion rectifier based power takeoff can be integrated into the point absorbers, wave attenuators, wave terminators, or other type of wave energy converter whenever oscillatory wave motion is involved. New extension has been made to simultaneously convert both ocean wave and marine current energy using a single power takeoff device.

Bio Sketch: Lei Zuo completed his PhD in Mechanical Engineering from MIT in 2004. After working on industry for four years, he joined in State University of New York in 2008 as an assistant professor and was promoted to associate professor in 2013. He moved to Virginia Tech in 2014 and was promoted to full professor rank in 2017. He currently serves the Associate Director of NSF Industry-University Collaborative Research Center for Energy Harvesting Materials and System. Since 2018 he has secured over 11 million US dollars of research funding ($9.5M as the PI), including $3M from US Department of Energy, National Science Foundation, Energy Protection Agency, National Academy of Sciences, New York and Virginia States on the design, dynamics, control of ocean wave energy conversion. Zuo has published over 200 papers in journals and conferences, including 5 with best paper and best student paper awards. He was named as the Fellow of the American Society of Mechanical Engineers (ASME) in 2016, and the sole recipient of the 2017 ASME Leonardo Da Vinci Award/Medal and the 2015 ASME Thar Energy Design Award. He also won R&D Awards twice (2015 and 2011) and a 2014 SAE Ralph R. Teetor Educational Award.