MECHANICAL ENGINEERING STUDENT SEMINAR

Wednesday, June 15 2022, at 13:30

Online: https://technion.zoom.us/j/95850570638

Development of an External Phase-Shifting Tunable Mechanism in a Miniature PT Cryocooler

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Cryogenics is the study of very low temperatures, effects they cause, and how to produce them. Many cryocoolers are based on the Stirling thermodynamic cycle, which traditionally makes use of two pistons and the expansion and compression of a gas to achieve a cooling effect. When reaching cryogenic temperatures, the piston at the cold side is almost always the cause for system failures. A cryocooler with no moving parts at its' cold end is very beneficial for reliability and lifespan purposes. The PT, or "pulse-tube" cryocooler, achieves exactly that by removing the cold side piston entirely. However, this reduces the effectiveness of the cryocooler, due to the gas' movement and pressure being out of phase. This effect is similar to the motion of a swing: there is a specific moment that the swing should be pushed to achieve maximum height, and if it is pushed at other times, it might not achieve that same height, or even be hindered. In the Rechler cryogenics lab, we develop this special type of cryocooler - the PT cryocooler – in miniature size, with additional benefits that make use of innovative technologies to improve performance and durability, robustness, flexibility, and ease of use. However, proper phase shifting has long been an obstacle for this cryocooler, due to the challenging conditions it is operated in. In addition, phase shifters are designed for very specific conditions, and a slight change in operation parameters limits the cryocooler's performance considerably, and traditional phase-shifters lose effectiveness when scaling down to suit the needs of our miniature PT cryocooler. Previous attempts in our lab laid the foundations for a solution but met with several challenges that prevented it from working properly. Therefore, this research deals with the development of a working phase-shifting mechanism to operate with the cryocooler, that makes use of electric generators (voice coils) to achieve a tunable phase shifting effect. Other research in this area primarily deals with general numerical and theoretical models for such a phase shifter, and not many attempts have been made to implement them into a real-life, working mechanism of this type. The suggested mechanism is compact, pressure driven, able to be externally tuned to different operation points, and tailored for the cryocooler. A comprehensive research and development process was performed, which included a theoretical background that enables a good understanding of the mechanism's behavior, simulations and calculations needed for the design, and a complete mechanical and electrical design of the mechanism. This mechanism was then manufactured, and experiments were performed to demonstrate its' operation and study its' behavior. The mechanism yielded good results, and smooth motion led to a proper, controllable phase-shift.

Note: the seminar will be given in Hebrew

Seminars Coordinator: Assoc. Prof. Matthew Suss.