



# Miniature Joule-Thomson Cryocooling: Principles and Practice (International Cryogenics Monograph Series)

*Ben-Zion Maytal, John M. Pfotenhauer*

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This book is the first in English being entirely dedicated to *Miniature Joule-Thomson Cryocooling*. The category of Joule-Thomson (JT) cryocoolers takes us back to the roots of cryogenics, in 1895, with figures like Linde and Hampson. The "cold finger" of these cryocoolers is compact, lacks moving parts, and sustains a large heat flux extraction at a steady temperature. Potentially, they cool down unbeatably fast. For example, cooling to below 100 K (minus 173 Celsius) might be accomplished within only a few seconds by liquefying argon. A level of about 120 K can be reached almost instantly with krypton. Indeed, the species of coolant plays a central role dictating the size, the intensity and the level of cryocooling. It is the JT effect that drives these cryocoolers and reflects the deviation of the "real" gas from the ideal gas properties. The nine chapters of the book are arranged in five parts.

- **The Common Principle of Cryocoolers** shared across the broad variety of cryocooler types
- **Theoretical Aspects:** the JT effect and its inversion, cooling potential of coolants, the liquefaction process, sizing of heat exchangers, level of pressurization, discharge of pressure vessels
- **Practical Aspects:** modes of operation (fast cooldown, continuous, multi-staging, hybrid cryocoolers), pressure sources, configuration, construction and technologies, flow adjustment, MEMS, open and closed cycle, cooldown process and similarity, transient behavior
- **Mixed Coolant** cryocooling: theory, practice and applications
- **Special Topics:** real gas choked flow rates, gas purity, clog formation, optimal fixed orifice, modeling, cryosurgical devices, warming by the inverse JT effect

The theoretical aspects may be of interest not only to those working with cryocoolers but also for others with a general interest in "real" gas thermodynamics, such as, for example, the inversion of the JT effect in its differential and integral forms, and the exceptional behavior of the quantum gases.

A detailed list of references for each chapter comprises a broad literature survey. It consists of more than 1,200 relevant publications and 450 related patents. The systematically organized content, arranged under a thorough hierarchy of headings, supported by 227 figures and 41 tables, and accompanied by various chronological notes of evolution, enables readers a friendly interaction with the book.

Dr. Ben-Zion Maytal is a Senior Researcher at Rafael-Advanced Defense Systems, Ltd., and an Adjunct Senior Teaching Fellow at the Technion-Israel Institute of Technology, Haifa, Israel.

Prof. John M. Pfotenhauer holds a joint appointment in the Departments of Mechanical Engineering and Engineering Physics at the University of Wisconsin - Madison.



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