

GUJARAT TECHNOLOGICAL UNIVERSITY

M.E. Semester: III

Mechanical Engineering (Cryogenic Engineering)

Subject Name **ADVANCED CRYO COOLERS**

Sr.No	Course content
1.	Cryocoolers: Classification of cryocoolers, Working of cryocoolers, Selection of cryocooler and comparison of different types of cryocoolers, Ideal working Cycles, Important parameters –mass, volume, vibration, acoustic noise, electromagnetic interface, operating life, Technical parameters - cooling effect, compressor power requirement, cooling water requirement, service requirement of compressor, Vibration control, Steady flow and oscillating flow cryocoolers, Different types of heat exchangers, Applications of cryocoolers –military, environmental, commercial, medical, transportation, energy, police and security.
2.	Gifford McMahon Cryocooler: Advantages and disadvantages of G-M cryocooler, Design of two stage G-M cryocooler, Efficiency of pressure oscillators, 4K operation, improved valve timing, Application of G-M Cooler, Monolithic regenerator technology for low temperature cryocoolers, Progress of multilayered regenerators.
3.	Stirling Cryocooler: Ideal Stirling cycle, Concept of practical Stirling cycle, First order analysis Stirling cycle, Second order analysis, Third order analysis, Loss analysis, Comparison of Stirling and Carnot cycle, Design and optimization of Stirling Cryocoolers, Performance and reliability improvement of low cost Stirling cooler, Development of long life stirling cooler, Analysis of Stirling Cycle, Multi stage Cryocooler, hybrid cooler, Long life tactical and commercial Stirling cooler, Miniature stirling cryocooler, Linear compressor design.
4.	Pulse tube Cryocoolers: Advantages and disadvantages of pulse tube cryocooler, History of pulse tube Cryocooler, Comparison of stirling and orifice pulse tube cryocoolers, Double inlet pulse tube refrigerator, Geometry of pulse tube –U-tube, co-axial, in-line, Two stage pulse tube refrigerator design, Thermoacoustically driven pulse tube refrigerator, Different methods of analysis, Phasor analysis, Oscillating flow behavior of PTR, Valve timing effect on performance of 4K pulse tube cryocooler. Design of Dual use PTR, Low vibration flexure bearing compressor, Miniature 50 K to 80 K space application of PTR, Experimental characteristics of PTR, Effect of D.C. flow, Active phase control of stirling type PTR, Expansion efficiency considering shuttle heat transfer, Co-axial PTR for high Tc- SQUID, Characteristics of Double inlet PTR, Experimental study and analysis of components of orifice pulse tube refrigerator. Theoretical model of G-M type pulse tube refrigerator, High frequency pulse tube cryocooler with base temperature below 20 K, Novel regenerator material Er ₃ Ni Hx-He-H ₂ mixture, Numerical and experimental study of Rotary valve for pulse tube, Valve timing effect on cooling performance of pulsetube cryocooler, V-M type PTR, Variable resistance orifice, Effect of valve timing on PTR, Performance of single stage pulse tube, Some of the phase shifting types of

	two stage G-M type pulse tube refrigerator, Small He3 PTR Multi stage pulse tube cooler 4 K technology - new material
5.	Space pulse tube Cryocooler development : Miniature pulse tube cryocooler for space, High frequency pulse tube cooler, High performance cryocooler compressor, Vibration reduction in balanced linear compressor, G-M type pulse tube cryocooler .
6.	Regenerator material analysis and material development Ductile, High heat capacity magnetic regenerator alloy material, Manufacturing considerations of rare earth powder used in cryocooler
7.	Dilution Refrigerator : Electrically driven 4 He circulating dilution refrigerator, Progress on microgravity Dilution refrigerator
8.	J-T Cooler: Advantages and disadvantages of J-T cooler, Recent advances –Mixed refrigerant, Sorption compressor, Electrochemical compressor, Mixture properties, Cool down characteristics miniature J-T cooler , Liquefaction of nitrogen using mixed refrigerant ,Further development ,Liquefaction of other gases, Modern trends in throttle cryocooler operating with mixed gas.
9.	Magnetic refrigerator: Magnetic refrigerator –Its development and its utility in magnetic hydrogen liquefier.
10.	Government Cryocooler development program Military space cryogenic cooling requirement, Linear drive Cryocooler for weapon system, Cryocooler reliability.

List of Experiments:

1. Comparative study of important and technical parameters of different Cryocoolers.
2. Preparation of theoretical model for generalized design of cryocoolers.
3. Detailed study (Design aspects) of cryocoolers for different applications.
4. Detail study of properties of different recent regenerator materials.
5. Study of analysis of Stirling cryocooler
6. Study of theoretical model of G-M type pulse tube cryocooler.
7. Comparative study of different geometry of pulse tube refrigerators.

Reference Books:

1. Cryocoolers by G. Walker
2. Cryocoolers Volumes (Proceedings of International Cryocooler conference)
Journal 'Cryogenics' published by Elsevier available at www.sciencedirect.com
3. Advances in Cryogenic Engineering. (Proceedings of International Cryogenic Engineering Conference)