Proceedings of the 9th World Congress on Mechanical, Chemical, and Material Engineering (MCM'23)
Brunel University, London, United Kingdom –August 06-08, 2023
Paper No. HTFF 169
DOI: 10.11159/htff23.169

Experimental Study to Enhance the Overall Cooling Capacity of Lanthanum Based Magnetic Refrigeration System

Sudeep Shankar[1], Manish Chandra[1], Satyanarayanan Seshadri[1]
[1]Indian Insritute of Technology, Madras
Chennai, India
am21s010@smail.iitm.ac.in; am17d300@smail.iitm.ac
satya@iitm.ac.in

Extended Abstract

Refrigeration accounts for 20% of electrical energy consumed by building according to the report by International Energy Agency (IEA). The demand for space cooling and heating is expected to increase 3 times in the near 2050. Refrigeration accounts for 7 to 8% of global greenhouse gas emissions[1]. The current existing technology of Vapour Compression Refrigeration System (VCRS) poses a great challenge to sustainability. The root cause is the usage of synthetic refrigerants which causes the emission of greenhouse gases. Magnetic Refrigeration is one of the emerging alternative to current technology of VCRS. The system works on a special property of material called Magneto-Caloric Effect (MCE). MCE is heating or cooling of material upon magnetization and demagnetization respectively. The refrigeration cycle is analogous to reverse brayton cycle where isentropic compression and expansion is replaced by adiabatic magnetization and demagnetization. A working prototype of MRS has been developed in our laboratory and able to achieve 30% cooling capacity of theoritical value [1]. The temperature span observed was around 0.85K. The selected permanent magnet for the prototype development is halbach magnetic array of strength 1.5 Tesla. The solid MCM used for development is based on La-Fe-Co-Si group compound. The curie temperature varies with the composition of La-Fe-Co-Si compound. The effect of magnetic field on MCM is higher at curie temperature and based on system requirement MCM has been selected. Instead of using single block of MCM we use an array of blocks of different compostion of MCM so that we can get a wide range of curie temperature. This array of MCM is called Active Magnetic Regenerator (AMR). A fluid has to be passed over the AMR which absorbs and gives heat to the system . When the MCM gets heated up during adiabatic magnetization, a room temperature fluid is passed over to absorb the heat and fluid flow is called hot blow. After adiabatic demagnetization, intially room temperature fluid is passed in a reverse direction that loses its heat to MCM and called cold blow. The system is designed for cooling application therefore cold fluid is of our interest. The cold fluid is stored in a tank and reutilized during next cycle of demagnetization to form a closed loop in AMR. The hot fluid may be stored or flushed out depending upon the application. The MCM is a ferrous based compound, it may get corroded depending upon the Heat Transfer Fluid (HTF) used. Due to this issue, the HTF has been limited to non-aqeous fluid. In our experiment, cal-77 a customized jet kerosene fuel is used as HTF. Analysis and solutions for the overall low cooling capacity of AMR is attempted.

The main objective of this study is to improve the overall cooling capacity by avoiding the mixing of hot and streams using active solenoid valves and maintaining vaccum conditions. The cooling capacity obtained is 18W which is 50% of theoritical value and a temperature span of 5K. This system can be further developed by atomizing the HTF resulting in enhanced heat transfer which in turn improves the overall cooling efficiency. This technology has potential to replace conventional VCRS if cooling capacity is enhanced further and it is also sustainable as the carbon dioxide emissions are negligible.

References

[1] "The Future of Cooling," Futur. Cool., May 2018, doi: 10.1787/9789264301993-EN.
[2] P. Singh, "Experimental Study to Enhance the Performance of Li-Fe-Co-Si Active Magnetic Regenerator for Room Temperature Cooling Applications," 2022,.