Abstract

Review of Superconducting Technology of MRI Scanners

MRI superconducting technology and its cryogenics can now look back at a history of over 30 years of successful operation and has since then seen considerable growth rates. Superconducting wires for MRI are now a commodity with affordable cost for low temperature applications, Over this timespan, MRI technology had the unique opportunity to permanently prove and reinvent itself and to mature, emerging as one of the most sophisticated and well-engineered Healthcare tools available in the world that saves millions of lives every year.

Looking back, first magnet designs relied on heavy weight, the simplest solenoidal configurations, quickly followed by breakthrough technology that used coil designs with field shaping shielding coils that allowed for easier installation and hospital siting. Challenging low-cost demands required continuous magnet optimization for overall size, FOV and material weight, e.g. reduced wire length and utilizing critical current (I_c) to its maximum possible limit.

Although 1.5 to 3 T mainstream systems are the current industry standard, there is still a need for coil designs for higher fields up to 7 T. An ultra-high field whole-body MRI system with a field of up to 11.75 T (Iseult) for advanced neurological studies is currently being assembled by CEA Saclay/Alstom, requiring pancake coil winding and continuous forced-flow cooling at 1.8 K.

Future magnet designs will look further towards medium or high temperature superconducting wire properties suitable for MRI, HTS SC joint-making and different distributed cooling methods to reduce liquid helium inventory.

From the applications point of view, the trend points towards dedicated systems that are targeting greatly increased S/N ratios for cancer research to study the metabolism of the human body at the molecular imaging level, scanners for selectively screening extremity parts and, most importantly, the development of dedicated brain research tools for understanding neurocognitive disorders, dementia, depression, Alzheimer's, traumatic brain injury, and stroke.

MRI magnet technology created a multi-billion dollar market at a time cryogenic infrastructure and SC wire technology was still in its infancy. This is an encouraging example for us all to take greater risks when building working prototypes and siting them in hospitals and research facilities, allowing them to show the full scope of functionalities and revealing their strength and weaknesses.

Other superconducting technologies may follow this example and the valuable lessons learned from it.