In spite of its recent discovery, MgB_2 has not only been routinely manufactured into long conductors, but useful examples of practical applications have been already realized. Some of them, using Columbus Superconductors products, are listed below as examples.

A. *MRI Magnets*

ASG Superconductors (ASG), a Company specialized in superconducting magnets manufacturing and associated with Columbus Superconductors, planned to design and manufacture an open MRI magnet based on the use of MgB_2-based conductors. This magnet is designed to reach a magnetic field of 0.5 Tesla in a free patient gap of about 60 cm. The magnet employs about 18 km of Columbus Superconductors MgB_2 multifilamentary tape, operated at 20 K with a cryogenic free cooling method (2 GM cryocoolers are entirely charged of keeping the system operational). The magnet was finally assembled and tested with positive results in July 2006.

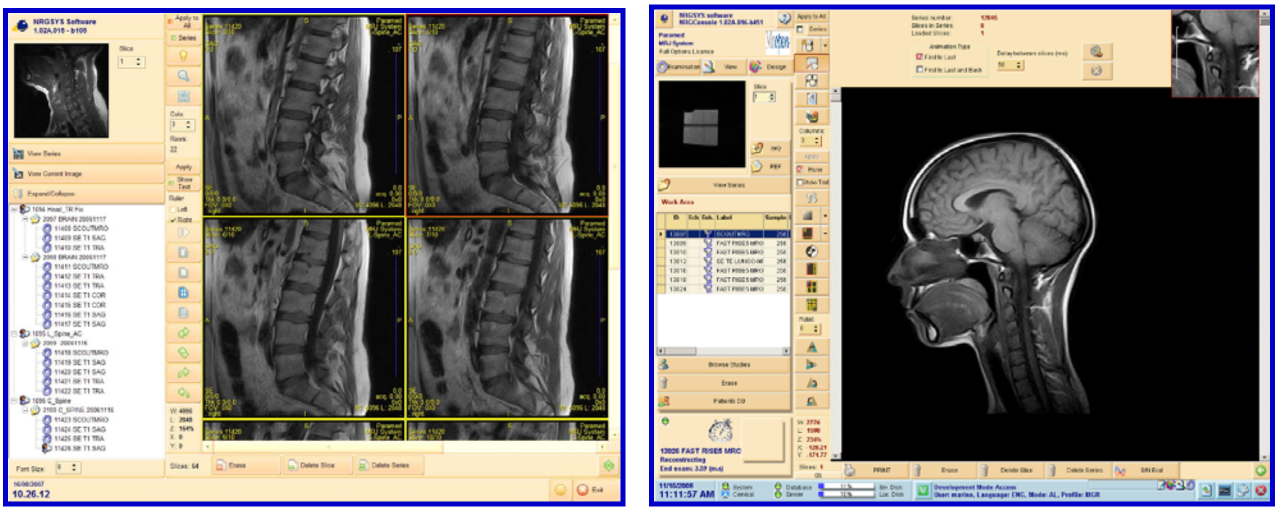
The ASG's MRI 0.5T cryogenic free magnet

This achievement confirms that the 18 kilometers of Columbus' MgB_2 conductor used to wind the coils are satisfying the requirements of an MRI system. The magnet reached its nominal current of 90 A, with maximum field on the conductor of 1.3 Tesla, and central field of 0.5 T without any training.
Paramed, a company specialized in medical systems associated with Columbus and ASG Superconductors, succeeded in turning this MgB_2-based magnet into the heart of a new generation of cryogen-free, "open-sky" MRI system. This revolutionary machinery is called MrOpen and, with its unique U-shaped design, patient claustrophobia is virtually eliminated by removing all barriers between the patient and the surrounding environment. The MrOpen

transverse magnetic field significantly improves image quality. The transverse field makes it possible to use phased array multichannel coils, combining flat coils with solenoid type coils. This technology maximizes the signal-to-noise ratio in all anatomical areas.

Mr Open The MRI 0.5T cryogenic free magnet

The first MRI images were successfully acquired in November 2006 and presented at RSNA 2006 in Chicago (USA). The first MRI image was a brain analysis.



Images acquired by Paramed Medical Systems on the MR-Open system. The brain image is by far the first one acquired by this system.

The first MrOpen system has been successfully installed in a private hospital in Sicily (South Italy). All the tests and the full industrialization have been successfully completed. The first installation was immediately followed by a second one, in a Canadian hospital, in Vancoover. This laid the foundations to the first large scale commercial application of MgB_2 superconductor out on the market. The production of the MgB_2 conductor necessary for this MRI system has given to the Columbus' factory a first continuous production rate for the conductors that has contributed to help to substantially reduce its production cost.

B. Fault current limiters (FCL)

In the recent years, several MgB_2 FCL prototypes were designed and built in the framework of the LIMSAT Italian project, aiming at the development of FCL under the coordination of CESI Ricerche SpA, a research center focused on the development of innovative technologies for the Energy sector. The test results of the FCL were in satisfying agreement with what expected from the transport properties of the conductor: the non inductive winding has reached a critical current in the order of 600 A.

These non inductive windings were tested with AC transport currents both in liquid helium and in liquid neon at different frequencies (2÷500 Hz) and different peak to peak currents, up to several times the I_c value.

Comprehensive short circuit testing have been performed in a closed cycle liquid neon system, in which gas that evaporates is re-condensed by the cold head of a Stirling cryocooler. The FCL has also survived the severe tests of multiple faults separated by a short time delay of about 300 ms.

Three of the 5 FCL prototypes produced

16133 GENOVA - ITALY
VIA DELLE TERRE ROSSE, 30
TEL. +39 010 8698 100
FAX +39 010 8698 110
www.columbussuperconductors.com
e-mail: info@columbussuperconductors.com

C. Solenoids

Several prototype solenoids were realized in the recent years with different MgB_2 superconductors and different winding technique, producing a central magnetic field up to 5 T .
However, the possibility to wind an already reacted conductor (*react and wind*, R&W) around a relatively small diameter bore without any degradation has been recently demonstrated with the realization and test of a solenoid R&W magnet wound on a 140mm inner diameter bore. This particular magnet has been built within a broad collaboration between several companies and institutes, coordinated by Texas Center for Superconductivity at the University of Huston, USA.

The solenoid made with 500 m of multifilamentary MgB_2 tape reached about the short sample critical current limit at 20K without any training. Such a magnet reached a central field of 1 Tesla at an operating temperature of 16K, corresponding to a current of 176 A. This magnet is only a first prototype, but its achievement already demonstrates the usability of MgB_2 conductors for a variety of applications such as electric space propulsion systems (Variable Specific Impulse Magnetoplasma Rocket, VASIMR). Critical current, weight and size will be further improved in the next steps of this research activity.

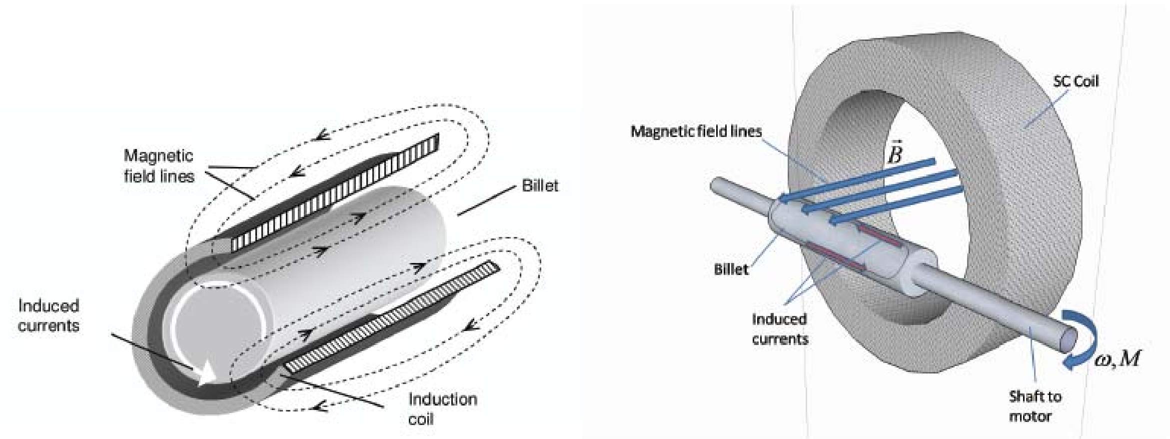
The 16K, 1 Tesla solenoid magnet realized with MgB_2 React & Wind conductor

D. Superconducting Induction Heater

ALUHEAT is a 3 years project, over in May 2008 and coordinated by Sintef Energy Reasearch. This project was focused on the production of a cryogen-free superconducting induction heater. In an induction heater the changing magnetic field induces eddy currents that heat up a billet placed inside the magnet. Conventional induction heaters use alternating current in a copper coil to create the changing magnetic field. Unfortunately, a significant ohmic losses are generated and the total efficiency decreases drastically. In a superconducting induction heater the total efficiency is improved but this cannot be done by simply feeding a superconducting coil with AC current, due to the AC losses of superconductors. The heating can be attained if a billet is rotated in an inhomogeneous DC magnetic field created with a superconducting coil. Since superconductors are

16133 GENOVA - ITALY
VIA DELLE TERRE ROSSE, 30
TEL. +39 010 8698 100
FAX +39 010 8698 110
www.columbussuperconductors.com
e-mail: info@columbussuperconductors.com

lossless at the direct currents, the input power is needed only to cool down the superconducting coil and rotate the billet.



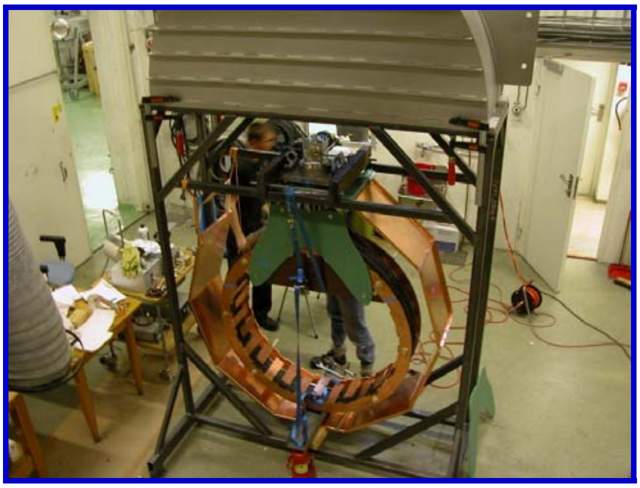
Principle of conventional induction heating (on the left) and principle of rotating billet superconducting induction heating (on the right)

The superconducting induction heater is more efficient compared to the conventional one when heating low resistivity materials like copper or alluminium. Efficiency in conventional induction heaters is only around 55%, whereas with superconductivity the efficiency can be increased to around 90%. This is substantial increase and since the total power of heaters usually exceeds 1 MW significant cost savings can be achieved.
More specifically, ALUHEAT project has been conceived to:

- develop technology to dramatically reduce energy consumption and thereby the life-cycle costs in one of the large-scale electrotechnical components with absolutely poorest energy efficiency;
- to validate the technical and economical feasibility of the new concept by building a 200-300kW aluminium billet induction heater and test it in an industrial aluminium extrusion plant.-
- to develop new technologies to be used to facilitate the introduction of superconductor technologies.

The importance of avoiding the use of a cryogenic liquid (LHe first) together with the low magnetic field required (1.5 T) and the availability of long enough Columbus' MgB_2-based conductors, contributed to envisage and finally to choose magnesium diboride for this application. 32 double pancakes, each of them composed by 550 m long MgB_2-based tape, have been constructed and successfully tested in the frame of this project, demonstrating the potency of the use of superconducting technology in this field.

16133 GENOVA - ITALY
VIA DELLE TERRE ROSSE, 30
TEL. +39 010 8698 100
FAX +39 010 8698 110
www.columbussuperconductors.com
e-mail: info@columbussuperconductors.com



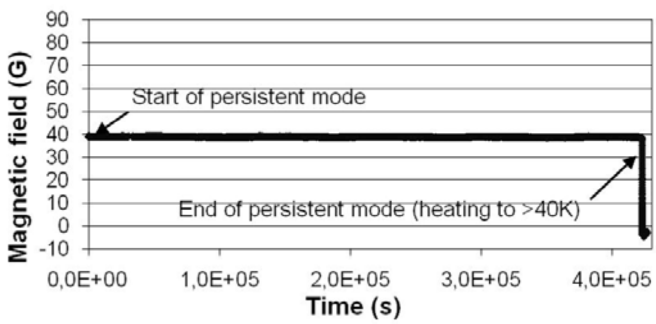
Superconducting coil under construction

E. *Superconducting Joints*

The possibility to use Powder In Tube (PIT) technique to produce superconducting wires with MgB_2 filaments, gave many scientists the confidence that a superconducting joint between MgB_2 conductors would have been successfully developed, sooner or later.

As a matter of facts, it was not easy to individuate the proper technique to manufacture such joints. Finally, after several attempts, ASG Superconductors was able to develop a reliable technique to join individual strands and producing an electrical joint resistance, well below the sensitivity of the experimental apparatus (i.e. fully superconducting joint) at a temperature of 30K and below.

The strand initially used for the joint was a mono-core strand with a pure nickel matrix. A persistent current estimated in 30-40 A was induced in the winding and kept unchanged at 20K for about 5 days ($4.2x10^5$ sec) without seeing any decay in the trapped magnetic field. By a rough calculation it has been estimated that the resistance of such a joint is < 10^{-14} ohm. Preliminary good results are also obtained using multifilamentary tape conductors.



The persistent self field was kept at 20K for about 5 days without any appreciable decay