An electrical power plug that connects by magnetism

Connecting and disconnecting electrical-power plugs, to and from their sockets, has become a routine action for everyone, especially with the increasing numbers of electrical, electronic and computing devices. The Institut NEEL is a partner in the project PRIMA («PRIse MAgnétique») which is developing a novel, quick-action magnetic connector. This connector exploits a strong magnetic field to guide the plug to its socket and to attach it firmly while, at the same time, providing complete security for both the user and the power or signal. In certain applications, it will also provide a «smart» connection with inbuilt intelligence for supervision and management of the electrical power transmission. The Institut NEEL's role is to provide its expertise in magnetic materials for the development of the powerful magnets to be integrated in these connectors.

Fig. 1

The two core elements of a simple, monophase magnetic plug (at left) and socket. More complex designs, can have up to 13 contacts.

When it is brought near its socket, this new power-plug (Fig. 1) orients and guides itself and snaps into place. To develop this concept, it was necessary to optimise the plug and socket design from the technical point of view while respecting the rules of eco-design, i.e. minimising both the environmental impact of the product during manufacture and its cost. In particular, the "magnets architecture" was developed specifically to minimize the quantity of magnetic material needed without compromising the magnetic field strength.

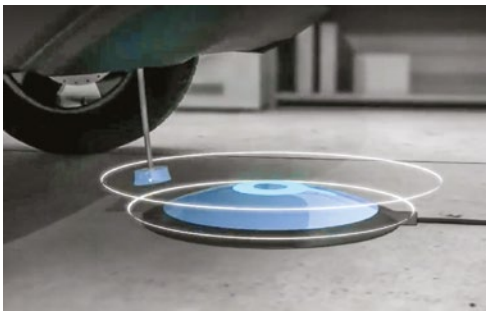
Commercial magnets are usually dense materials, mostly made by sintering i.e. heating a "green" compact of the magnetically-oriented powder of the magnetic material to form a solid block. This new connector will use "bonded" magnets, made by binding magnetic particles together with a polymer matrix. Bonded magnets can be manufactured using extrusion processes which produce long spaghettis that are then cut into pellets (a process called granulation). This compound (Fig 2) can be readily formed into complex shapes, without any machining, by injecting it into a heated mould.

To select powders to meet the specifications of the PRIMA project, the Institut NEEL participants have worked on the composite material, conducting a wide range of experiments to study the influence of multiple parameters : types of powder (isotropic or anisotropic), choice of bonding matrix polymer, and phase fraction in the compound, process parameters, etc. Our bonded materials were injected into moulds to determine the optimum injection parameters for each type of material mixture, and to determine the process's limits, For that purpose, we characterized and tested our bonded magnets mechanically, structurally (Scanning Electron Microscopy and X-ray Diffraction), and magnetically. In particular, the magnets were tested up to 7 Teslas in the laboratory's high field superconducting magnets. The final choice of material and process, as developed at the NEEL Institute, was then transferred to the industrial partners in charge of the magnet production.

Fig. 2

The composite magnetic material, cut into pellets of optimum size for injection into the mould which shapes a magnet (pellet lengths approximately 5 mm).

Fig. 3



A prototype charging system for the battery of an electric automobile. The car driver needs only to position the vehicle approximately, and the electrical cable & plug unit guides itself magnetically to the power socket. Recharging is initiated without the driver's intervention.
(Courtesy Gulplug , https://www.gulplug.fr/)

This project groups eight participants, including the designers and the manufacturers of the magnetic connectors, and two final commercial users, leaders in their respective markets. The CNRS is involved as concerns both the magnetic materials development and characterization (Institut Néel) and the magnets architecture (Grenoble Electrical Engineering GEE-Lab). The project received funding from BPIfrance the pôles de compétitivité (competitivness clusters) Plastipolis and Minalogic, and the local authorities.

Some of the applications envisaged for these electrical connectors, ranging from 12 to 240 Volts, are : Rapid connectors for the automobile industry (e.g. see Fig. 3), robotics applications, electric wheel-chairs and other devices for the health sector, fully waterproof electrical sockets, e.g. for nautical applications.

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FURTHER READING...

"Electrical Plug and Socket Assembly"
J.P. Yonnet
Patent WO/2017/001755 (Jan. 2017).