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Electrical Steel for Hybrid Vehicles

Highest grade works at the heart of eco-friendly motors.

Electrical steel sheets are prime candidates for the core material of hybrid-vehicle motors. Highlighted below are the role and new possibilities of Nippon Steel’s electrical steel sheets in the enhancement of electric-vehicle performance.

Electrical steel sheets as the cores of electric equipment are essential for modern society. Nippon Steel has long led the world in electrical steel sheet production, and is also the leader in the supply of the highest-quality electrical steel sheets for generators, transformers, motors and other electric equipment.

Higher-efficiency Motors Accelerate the Diffusion of Hybrid Vehicles

Hybrid vehicles offer two major advantages. The combined use of an electric motor and an engine permits downsizing of the engine. Because of the operation of engines within the highest energy efficiency range, fuel consumption can be cut by half and accordingly exhaust emissions can be reduced.

On the other hand, motors, batteries and control systems are fitted to hybrid vehicles, entailing higher vehicle cost. This drawback, however, is being met head-on. Technological innovation and the merit of improved fuel economy in particular more than offset the cost increase, and are expected to spur the popularity of hybrid vehicles. Specifically, the key will be technological innovation in the aspect of motors.

Because the motor is a power source for the hybrid vehicle, expectations are especially high for its technological improvement. Electricity generates magnetism. The magnetism that permeates steel sheets (the core in a motor) produces the rotational motion of a motor. Accordingly, elec-
Nippon Steel’s Electrical Steel is the Material of Choice for Users

Nippon Steel markets the highest-quality electrical steel sheets for motors, which offer compatible performances of low core loss and high magnetic flux density. These electrical steel sheets have gained high marks, and the largest share, in the hybrid-vehicle market. A major factor in this high market acceptance lies in Nippon Steel’s accurate response to two major requirements for hybrid-vehicle motors.

One is that to extend the travel range with finite battery capacity, the motor power loss must be controlled to a minimum. Also necessary is the efficient conversion of the energy generated at the time of decelerating (regenerative energy) into motive power. When magnetism permeates electrical steel sheet, variation, if any, in the grain orientation of the sheet impedes magnetism and generates heat. This heat is called core loss. It is useless energy, causing only power loss. Therefore, electrical steel sheet is required to have grain alignment in a single direction so as to allow magnetism to permeate unimpeded and to ensure minimum power loss.

The other requisite for motors is the capability to produce high torque. Nippon Steel’s electrical steel sheet allows the permeation of a large quantity of magnetism even through its narrow paths — high magnetic flux density. Thus, it permits higher torque and downsizing of motors. Quality electrical steel sheet is defined as that which features low core loss and high magnetic flux permeation.

A marked strength of Nippon Steel is its comprehensive technological capability to respond to these diverse needs. For instance, even with good design and quality electrical steel sheet, a high-performance motor is not necessarily achieved. Of extreme importance to this end is all-embracing application know-how,
from fabrication to shapes, treatment and all other factors to realize optimum performance in conformity with the design, i.e. advanced application technology.

Concerning such application technology intermediate between design and material, Nippon Steel can also come up with superb application proposals, which are highly rated among users. Nippon Steel accounts for the largest share of the world’s production of electrical steel sheets with its rich product line-up and thus is always ready to tackle diverse problems facing customers. This positive attitude serves as prime mover in the development of advanced materials and application technology.

Based on its established materials technology, Nippon Steel is firmly committed to rendering extensive services, including application technology, of higher added value. The company precisely responds to customer needs, while also contributing toward energy saving worldwide and conservation of the global environment.
Enhanced canmaking steel materials — thin and light, tough and workable — are a product of advanced steel sheet technology.

Tinplate produced at Nippon Steel’s Yawata Works accounts for approximately 20% of all steel canmaking and other container materials in Japan. Canmaking tinplate introduced at Yawata typifies the quality of the wide range of steel sheets being supplied by Nippon Steel. Yawata Works started production of tinplate in 1923 to meet the demand for domestic production of canned foods. Tinplate production at Yawata spearheaded the subsequent development of steel sheet technology in Japan.

Japan’s first cold-strip mill started operation at Yawata Works in 1940, making possible mass production of steel sheets. The mill was imported from the United States. In the 1950s, demand for canned food for export such as canned mandarin oranges grew, and the need for low-cost steel cans arose. To meet the need, Yawata Works introduced from United States Steel in 1955 electrolytic tinning line technology to replace hot-dip tinning. Exports of electrolytic tinplate thus produced to American Can Company, then the largest canmaking company in the U.S., resulted in acquiring high user assessment worldwide. Yawata’s tinplate production increased rapidly, accounting for more than 90% of national production by 1969.

To meet beverage can demand, a challenging task for Yawata Works has been the development of canmaking steel sheets that are high in corrosion resistance, thin, and low in cost. Yawata achieved three breakthroughs: development of tin-free steel in 1966, full-scale production of extrathin tinplate in 1968, and supply of tinplate for steel DI cans in 1973.
Research on Interface Technology Continues for Fifty Years

Research started at Yawata Works in 1957 on tin-free steel (TFS), canmaking steel sheet that requires no expensive tin. TFS has a two-layer structure: oxidized chromium film as the top layer and metallic chromium as the lower layer. The key to TFS was the technology to control micrometer-order film thickness. It satisfied diverse performance requirements: corrosion resistance, paintability, heat resistance, chemical resistance, formability and printability. TFS production started in 1966. The current brand name is TINFREE STEEL. In the following ten years, its accumulated production reached as high as 1.4 million tons. Surface treatment technology of canmaking steel sheets shifted from electrolytic tinning to TFS.

A noteworthy attainment in TFS is the interface technology to control the two boundary faces in contact. Interface engineering is common in the field of electronics and semiconductors. But fifty years ago Yawata Works had already made extensive headway in interface engineering: the interface control to form a film one micrometer or less on a steel sheet 200~300 micrometers thick.

Lightest-weight and First Steel DI Cans on the Market

Entering into the 1960s, tinplate gauge reduction quickly advanced. Yawata Works developed extrathin tinplate (2CR) with excellent formability, and in 1968 started its full-scale production for beer and carbonated beverage cans. The 2CR tinplate technology further accelerated tinplate gauge reduction, leading to 0.18 mm thick tinplate, the world’s thinnest now on the market. A significant achievement brought about by thinner gauges is that steel beverage cans now weigh about 60% less than those in the 1950s.

Nippon Steel and Daiwa Can Company, a Nippon Steel affiliate, jointly directed research endeavors toward the shift from aluminum to steel in DI (drawn and ironed) can production. In 1973, supply of the world’s first steel DI cans started. A breakthrough attained in the tinplate process was C.A.P.L. (continuous annealing and processing line) for the production of base steel sheets for tinplate, put into operation in 1982 at Yawata Works ahead of other tinplate makers. C.A.P.L. allowed stable forming of
Canmaking Steel Sheets

DI cans and made possible cost cutting and drastic reduction in delivery time. It not only reduced production lead time from seven days to a mere several minutes, but also yielded uniform product quality. As a result, steel DI cans surpassed the quality and productivity of aluminum DI cans.

0.18 mm Thick Material Allows Lower Can Cost

Film-laminated cans are in demand to replace painted cans. Nippon Steel jointly with canmaking companies has started the supply of film-laminated steel cans — TULC (Toyo Ultimate Lightweight Can) with Toyo Seikan Kaisha and laminated welded cans with Daiwa Can Company.

Nippon Steel is supplying 0.18 mm-thick extra-thin tinplate for TULC, acquiring high user assessment. It is a world-class lightweight and highly workable material for use in 350 milliliter cans. Its application has permitted weight reduction of steel cans — about 15% per 350 milliliter can and about 38% per 200 milliliter can — over conventional canmaking materials. In the field of steel DI cans, Yawata Works is marketing 0.19 mm extra-thin tinplate, contributing to resources saving and weight reduction of steel cans.

Technology to pursue steel sheet gauge reduction has yielded considerable achievements in the last 80 years. These technological achievements will serve as the basis to promote further performance enhancement of steel sheets and accurately meet the emerging social needs in the age of growing environmental concerns.