Improved Thermoplastic/Iron-Particle Transformer Cores

Proper choice of particle-size distribution results in minimal eddy-current loss.

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A method of fabricating improved transformer cores from composites of thermoplastic matrices and iron-particles has been invented. Relative to commercially available laminated-iron-alloy transformer cores, the cores fabricated by this method weigh less and are less expensive. Relative to prior polymer-matrix/iron-particle composite-material transformer cores, the cores fabricated by this method can be made mechanically stronger and more magnetically permeable. In addition, whereas some prior cores have exhibited significant eddy-current losses, the cores fabricated by this method exhibit very small eddy-current losses. The cores made by this method can be expected to be attractive for use in diverse applications, including high-signal-to-noise transformers, stepping motors, and high-frequency igniton coils.

The present method is a product of an experimental study of the relationships among fabrication conditions, final densities of iron particles, and mechanical and electromagnetic properties of fabricated cores. Among the fabrication conditions investigated were molding pressures (83, 104, and 131 MPa), and molding temperatures (250, 300, and 350 °C). Each block of core material was made by uniaxial-compression molding, at the applicable pressure/temperature combination, of a mixture of 2 weight percent of LaRCTM (or equivalent high-temperature soluble thermoplastic adhesive) with 98 weight percent of approximately spherical iron particles having diameters in the micron range. Each molded block was cut into square-cross-section rods that were used as core specimens in mechanical and electromagnetic tests. Some of the core specimens were annealed at 900 °C and cooled slowly before testing. For comparison, a low-carbon-steel core was also tested.

The results of the tests showed that density, hardness, and rupture strength generally increased with molding pres-
Cooperative Lander-Surface/Aerial Microflyer Missions for Mars Exploration

Bio-inspired principles of key functions are distilled, enabling missions to Mars using multiple microflyers in synergy with the existing surface assets to provide a robust telecommunication architecture for gathering scientific data.

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Concepts are being investigated for exploratory missions to Mars based on “Bioinspired Engineering of Exploration Systems” (BEES), which is a guiding principle of this effort to develop biomorphic explorers. The novelty lies in the use of a robust telecom architecture for mission data return, utilizing multiple local relays (including the lander itself as a local relay and the explorers in the dual role of a local relay) to enable ranges ~10 to 1,000 km and downlink of color imagery. As illustrated in Figure 1, multiple microflyers that can be both surface or aerially launched are envisioned in shepherding, metamorphic, and imaging roles. These microflyers imbibe key bio-inspired principles in their flight control, navigation, and visual search operations. Honey-bee inspired algorithms utilizing visual cues to perform autonomous navigation operations such as terrain following will be utilized. The instrument suite will consist of a panoramic imager and polarimetric imager specifically optimized to detect ice and water. For microflyers, particularly at small sizes, bio-inspired solutions appear to offer better alternate solutions than conventional engineered approaches.

This investigation addresses a wide range of interrelated issues, including desired scientific data, sizes, rates, and communication ranges that can be accomplished in alternative mission scenarios.

The mission illustrated in Figure 1 offers the most robust telecom architecture and the longest range for exploration with two landers being available as main local relays in addition to an ephemeral aerial probe local relay. The shepherding or metamorphic plane are in their dual role as local relays and image data collection/storage nodes. Appropriate placement of the landing site for the scout lander with respect to the main mission lander can allow coverage of extremely large ranges and enable exhaustive survey of the area of interest. In particular, this mission could help with the path planning and risk mitigation in the traverse of the long-distance surface explorer/rover. The basic requirements of design and operation of BEES to implement the scenarios are discussed. Terrestrial applications of such concepts include distributed aerial/surface measurements of meteorological events, i.e., storm watch, seismic monitoring, reconnaissance, biological chemical sensing, search and rescue, surveillance, autonomous security/protection agents, and/or delivery and lateral distribution of agents (sensors, surface/subsurface crawlers, clean-up agents). Figure 2 illustrates an Earth demonstration that is in development, and its implementation will illustrate the value of these biomorphic mission concepts.

This work was done by Sarita Thakoor and Norman Lay of Caltech for NASA’s Jet Propulsion Laboratory and Butler Hine and Steven Zornetzer of Ames Research Center for the NASA Intelligent Systems Program. Further information is contained in a TSP (see page 1).

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