

Low frequency induction heating of 3D printed composites: Toward medical applications.

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Keywords: Ferromagnetic composites, hysteresis loss, low-frequency induction heating, 3D printing.

3D printing of magnetic composites like polymer matrix field with magnetic particles allows achieving systems with complex geometries as well as structural/functional properties [1][2]. In this study, we focus on low-frequency induction heating (LFIH). The principal benefits of LFIH over other heating methods are selectivity of the heated area, fast response time, and good efficiency [3]. Such properties suit perfectly medical applications. The LFIH effect in ferromagnetic composites appears as soon as the treated sample is exposed to an alternating magnetic excitation field and is mainly due to the so-called "microscopic" eddy currents linked to the magnetic domain wall motions [4]-[7].

A 3D printed ABS thermoplastic filled with 17% vol. magnetite iron oxide (Fe_3O_4) will be used for the experimental validation. A specific test-bench was developed using a modified high speed DC motor and a magnetic inductor made of 8 permanent magnets to produce an alternative excitation magnetic field (Fig. 1(a)). As illustrated in Fig. 1(b), the temperature of the sample increased significantly as a function of the magnetic excitation frequency, confirming the frequency dependence of the hysteresis losses through the sample. First experimental results show a promising increase of 14°C under a 400Hz-applied magnetic field, confirming the potential of the proposed material for LFIH applications. In Fig. 2 (b) a comparison with a conductive but non-ferromagnetic samples made on ABS polymer matrix doped by conductive particles like carbon black is proposed. As theoretically envisioned, this new composite exhibits very weak response to the magnetic field excitation and no temperature effect can be observed with the thermal camera. This observation can be explained from the "microscopic" eddy-current consideration, i.e. the domain wall motions are predominant mechanisms under low frequency, leading to local temperature variations inside the ferromagnetic particles. These preliminary results seem to be promising. Such effect could be used especially for the treatment of varicose veins or the cancer magnetic hyperthermia where local heating is still a real challenge nowadays

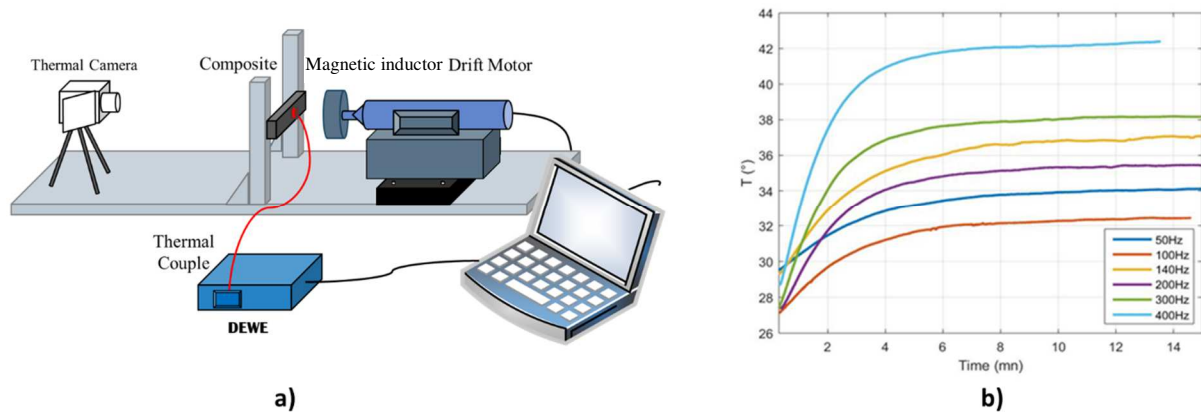


Fig. 1. a) Experimental dispositive, b) Time variation of temperature for different level of excitation.

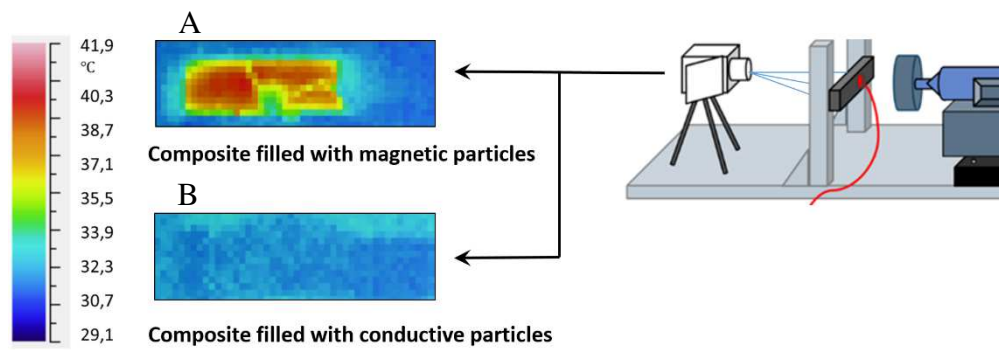


Fig. 2. LFIH thermal camera observation under steady state 400Hz AC magnetic field excitation.
 (A) Ferromagnetic composite. (B) Conductive composite.

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