Induction heating properties of ferromagnetic composite for varicose veins healing

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Key words

Ferromagnetic composites, hysteresis loss, low-frequency induction heating, varicose veins healing.

Abstract

In this study, we investigate ferromagnetic composites made of ABS thermoplastic matrix fulfilled with iron oxide particles (Fe_3O_4). The low frequency induction heating effect (LFIH) in such composites is mainly due to the hysteresis losses linked to the magnetic domain's wall motions under low frequency alternating magnetic excitation fields [1][2][3]. Therefore, LFIH can be used as varicose veins treatment. In the future, the LFIH method will probably outclass the existing treatment methods as its performances in terms of precision, cost and applicability seem much better [4].

For the hysteresis characterization of the magnetic properties and validation of the LFIH method, samples with different shapes and particle volume fractions were built. Magnetic properties such as hysteresis cycles, permeability, remnant inductions, and coercive fields … were measured using the experimental test bench illustrated in Fig. 1. For the validation of the LFIH method, a specific experimental test-bench was developed. This new set-up is shown in Fig. 2. An alternative magnetic field with significant amplitude under a frequency range varying from a few hundred Hz to 2.5 KHz was generated by an inductor made of 8 strong permanent magnets located on a high speed electric motor rotating output shaft.

A significant temperature increase of the ferromagnetic composite was observed by the thermal camera after 5 minutes, as illustrated in Fig. 3 a). To highlight the ferromagnetic composites induction heating effect, a comparison with electrically conductive but non-ferromagnetic samples was performed. In Fig. 3 b), as opposed to the ferromagnetic composite, the conductive sample exhibited a very weak response to the magnetic field excitation and no temperature variation was observed.

The temperature variations of the ferromagnetic composites confirmed their potential as local heating and healing treatment for medical applications. Characterizations under simultaneous magnetic and thermic excitation also revealed very stable magnetic properties (stable permeability can been achieved on a very large temperature range) confirming the reliability of the developed composite magnetic properties.

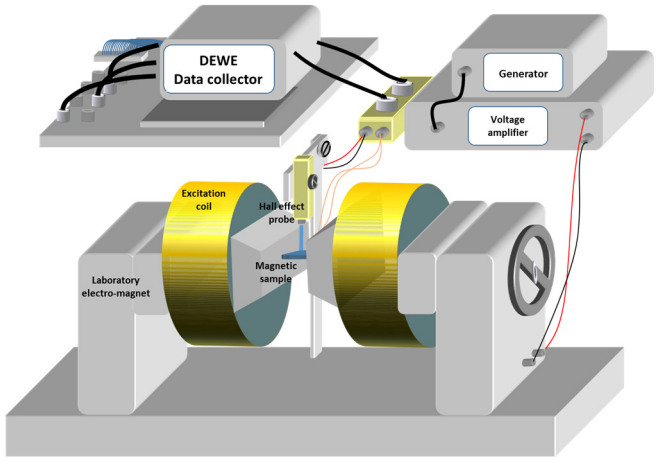

Figure 1. Experimental setup for the magnetic characterization of the magnetic composites.

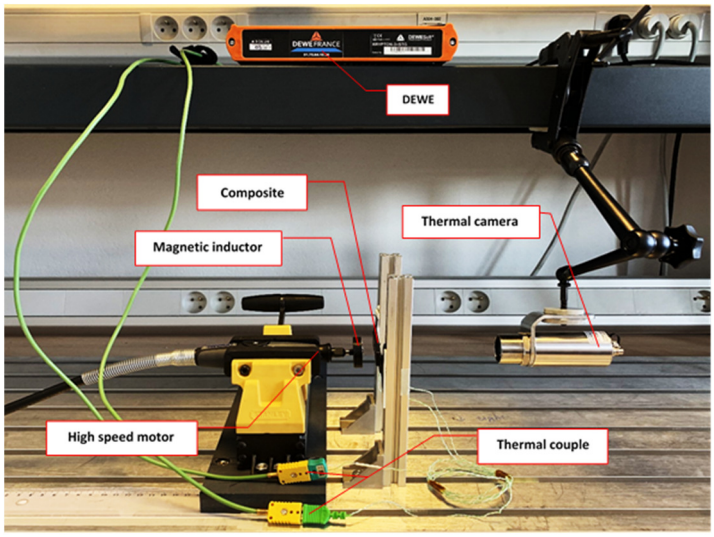

Figure 2. Experimental setup for the induction heating effect.

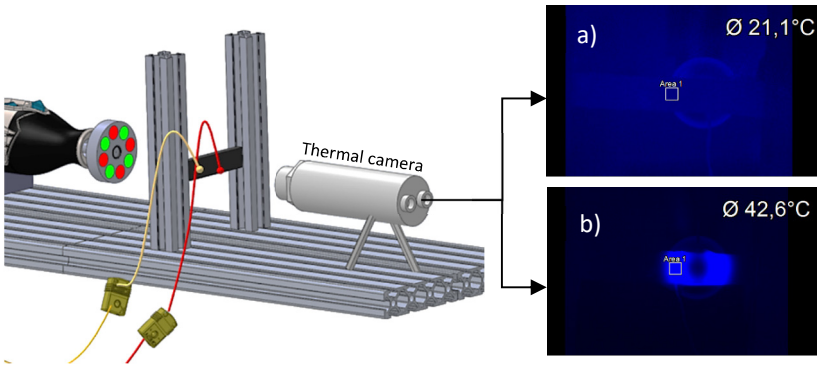

Fig. 3. LFIH thermal camera observation under steady AC magnetic field excitation.
a) Conductive composite. b) Ferromagnetic composite.

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