Thermoplastic nanocomposites with magnetic nanoparticles for bonding and debonding on demand applications by local induction heating

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Induction heating is a convenient and flexible method to deliver high-strength magnetic fields to ferromagnetic nanoparticles, which act as susceptors, generating heat in nanocomposite materials by hysteresis [1]. Taking advantage of the induction heating mechanism, nanocomposite materials embedded with magnetic nanoparticles (MNPs) constitute promising materials for adhesive joining systems, enabling reversible joining procedures, providing easy-to-disassembly operations by induction disassembly [2].

Nanocomposite filaments for Additive Manufacturing, reinforced with MNPs were used to investigate the heating capacity, using induction heating technology. Thermoplastic (TP) matrices of polypropylene (PP), polyurethane (TPU), polyamide (PA12) and polyetherketoneketone (PEKK) were compounded with 2.5, 5, 7.5, and 10 % wt. iron oxide nanoparticles (Fe_3O_4). MNPs were introduced to the polymers matrices by a twin-screw extrusion system, following appropriate temperature profiles. After the extrusion, nanocomposite specimens were prepared either by thermo-pressing in molds or by 3D printing. Heating capacity of specimens was examined as a function of time in a radiofrequency (RF) generator with a solenoid inductor coil, varying the working parameters (i.e., maximum power, frequency, time).

All nanocomposite specimens presented temperature increase proportional to the MNPs concentration as a function of exposure time in magnetic field. Specifically, specimens with higher concentration of MNPs showed more rapid temperature increase, resulting in melting state in the most of trials. Nanocomposites of PP, TPU, and PA12 with 10% wt. MNPs reached their melting temperature in less than 2 minutes of exposure in a magnetic field of 585 kHz frequency. In case of PEKK, a lower concentration of MNPs is preferable, since PEKK is more demanding during the extrusion process. Specimens of PEKK with 2 % wt. presented an increase of temperature after 5 minutes of exposure in magnetic field. However, the heating capacity was not sufficient to melt PEKK nanocomposite. The working parameters of the RF generator, such as frequency and input power, significantly affect the heating capacity of MNPs [3]. Using a coil with solenoid geometry, higher input power and frequencies promote the rapid increase of temperature of all nanocomposites. Developing innovative TP nanocomposites will allow a faster and leaner integration and repair of 3D printed structures, compared to thermoset repair processes, promoting advanced applications in many fields of Nanotechnology.

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