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FRENETIC APPLICATION NOTE

ADDITIVE MANUFACTURING TECHNIQUE FOR 3D-PRINTING FERROMAGNETIC MATERIALS

Ferrite cores for power electronics applications are manufactured with a sintering process, which consists on simultaneously pressing and heating powder to provide its final geometrical, magnetic, and mechanical properties.

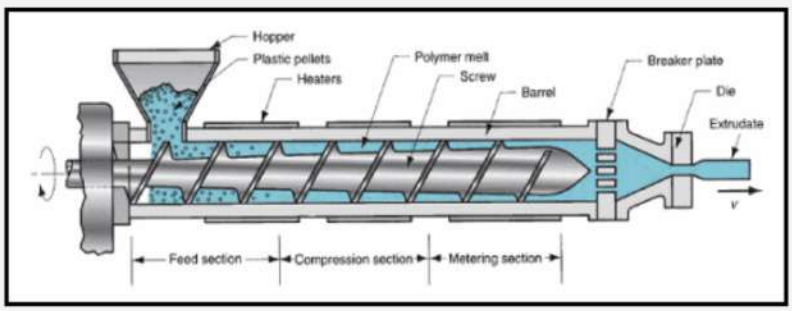
In this application note, a different manufacturing technique is described: a binder solution is used in an extrusion process to keep together different ferromagnetic particles. This allows the material to conduct magnetic flux, while having very large electrical resistivity, low permeability, and, with low powder proportion, the proper characteristics for 3D printing.

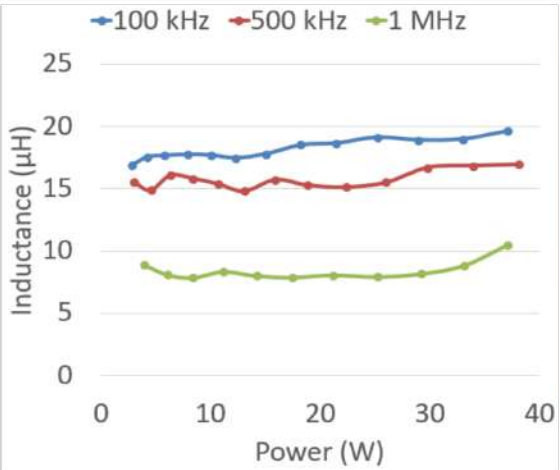
There are two main applications for these materials: on one hand, the engineer is able to configure ad hoc the desired equivalent permeability with the material composition, so no air gap is necessary. With 3D-printed designs, more complex geometries can be achieved with acceptable A_L, but this technology is not mature yet. On the other hand, these low-permeability materials can be used as shunts for complex magnetic structures or to be put in the gap, so it becomes distributed and fringing losses are reduced.

$$\mu_e = \mu_0 \frac{\mu_r}{1 + \mu_r \frac{g}{l_e}}$$

MANUFACTURING PROCESS

Manufacturing of these new materials is based on a simple polymer screw extrusion. Plastic pellets are mixed together with ferromagnetic powder in the hopper. The resulting mixture is then heated up and pressed together as it advances due to the screw's rotation movement. This causes the polymer to melt and trap the ferromagnetic particles. With enough control of the process, the resulting extruded filament has homogeneous magnetic properties. Then, this filament can be put into a 3D printer to generate any desired custom core shape, magnetic shunt, or gap.





CONCLUSIONS

Additive manufacturing techniques can improve the performance of magnetic components. Components manufactured through these processes have higher flexibility and can be easily customized for specific applications. Their microstructure favors low eddy current losses, as well as lower fringing losses when placed instead of the air gap.

In contrast, these methods do not provide yet a fast production cycle, so they don't have a good scalability for large production volumes. Lower permeability also implies worse coupling between windings when used in the entire core.

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