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QUANTITATIVE MOISTURE ANALYSIS IN COMPOSITES USING A CLINICAL MRI SYSTEM

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ABSTRACT

The absorption of moisture is one possible cause of ageing and deterioration of a composite material. Especially within the aerospace and renewable energy industries profitability depends on long service life and thus the detection and analysis of moisture ingress is an ongoing subject of research [1]. It has previously been shown that the three-dimensional detection of signal from hydrogen nuclei in several polymer samples is possible using a clinical magnetic resonance imaging (MRI) system with an ultra-short echo time (UTE) sequence [2].

The goal of this study was to detect the signal of moisture in fibre-reinforced polymers and to evaluate the possibility of determining quantitative MR parameters. Therefore, several samples of glass-fibre-reinforced polymers were artificially aged using an autoclave for accelerated moisture absorption and their weight was recorded on a weekly basis. Volumetric MRI data was acquired using a 3D UTE sequence at a resolution of 1 mm^3 and the effective transverse relaxation time T2 was evaluated throughout the volumes of the specimens. Consequently, it was shown that the signal sufficed for qualitative three-dimensional mapping of the moisture signal. Furthermore, three-dimensional T2* maps were calculated which revealed a linear relationship between mean T2* values and the amount of absorbed moisture in the samples.*

Keywords: moisture analysis, fibre-reinforced polymers, magnetic resonance imaging, moisture detection, accelerated ageing

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REFERENCES

[1] Jones F.R., Foreman J.P., "*The response of aerospace composites to temperature and humidity*", In Polymer Composites in the Industry, Pages: 335-369, ISBN: 978085709523, 2015

[2] Springer F., Martirosian P., Schwenzer N.F., Szimtenings M., Kreisler P., Claussen C.D. and Schick F., "*Three-dimensional ultrashort echotime imaging of solid polymers on a 3-tesla whole-body mri scanner*", Investigative Radiology, Vol.: 43 (11), Pages: 802-808, ISSN: 0020-9996, 2008

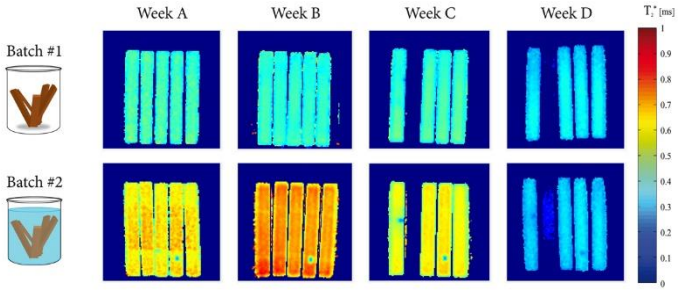

Figure 1: Horizontal cross sections of 3D T2* maps of two GFRP sample batches at several weeks of MRI acquisition and conditioning in an autoclave. Batch #1 was autoclaved in vapor, whereas batch #2 was autoclaved while submerged in water. Various effects are visible: loss of signal after drying, as well as impact damage in the first specimen of batch #2 in weeks C&D. Furthermore, a spherical area of signal loss due to possible sizing-free area is visible in the fourth sample from left in batch #2.