HiPerDuCT Programme Grant
Final report: Aligned Discontinuous Fibres

The High Performance Discontinuous Fibre (HiPerDiF) technology allows to produce Aligned Discontinuous Fibre Reinforced Composites (ADFRC) with mechanical properties comparable to those of continuous fibre composites manufactured with the same constituents [1,2,3]. The HiPerDiF discontinuous fibre alignment method exploits the sudden momentum change of a jet of fibres suspended in water directed in a narrow gap between parallel plates.

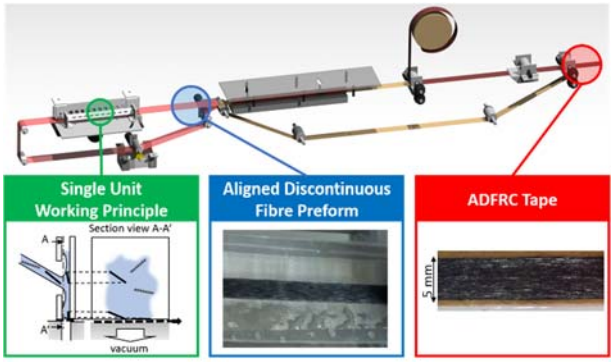

Figure 1. HiPerDif machine schematic and working method [4]

If the fibres are longer than the critical length, pseudo-ductility can be achieved in ADFRC through three different methods of hybridization: intermingled hybrids [5], intraply hybrids [6], and interlaminated hybrids [7]. In all cases, the ductile response is achieved through fragmentation and diffuse debonding or delamination of the low elongation reinforcement. Different types of hybrid can be organised in a hierarchical structure to further enhance the pseudo-ductile behaviour [8]. If the fibres are shorter than the critical length the pseudo-ductile behaviour is achieved through a fibre pull-out mechanism [9].

Intermingled Hybrids

Intermingled ADFRC hybrids containing High Modulus low strain Carbon and Glass or High Strength Carbon fibres with high strain allow pseudo-ductile behaviour to be achieved through fragmentation of the low strain fibres [5,8]. This has been demonstrated also for quasi-isotropic laminates [10].

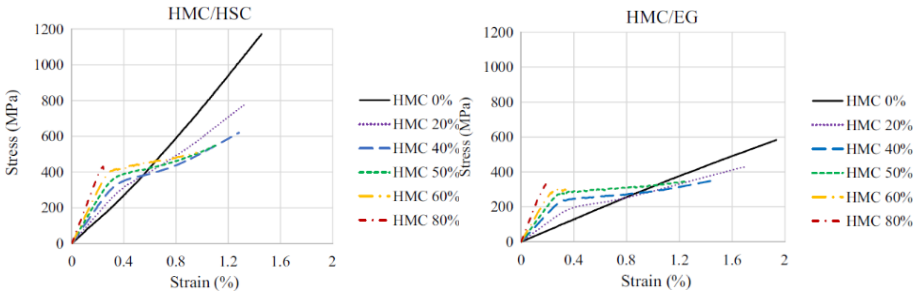

Figure 2. Pseudo-ductile intermingled ADFRC hybrids behaviour [8]

Interlaminated Hybrids

Interlaminated hybrids are made of a central thin layer of ADFRC sandwiched between continuous high elongation fibres, e.g. glass fibres. Through the use of Damage Mode Maps is possible to tailor the cross-section to achieve a pseudo-ductile behaviour [6,8,11,12].

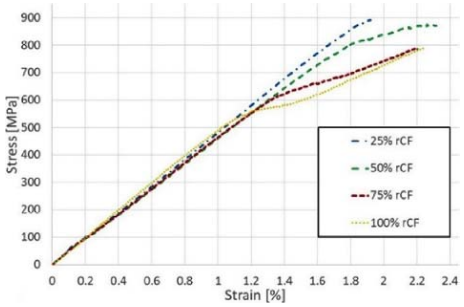

Figure 3. Pseudo-ductile interlaminated hybrid behaviour [6]

Intraply hybrids

Thanks to its modular design the HiPerDiF machine allows manufacturing intraply hybrids able to provide pseudo ductile behaviour [7,13].

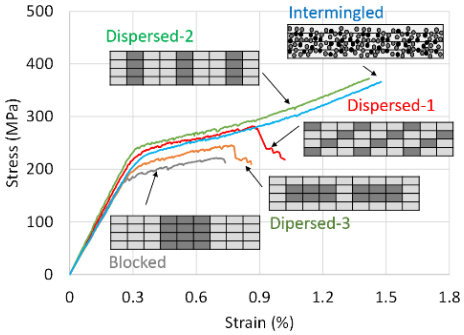

Figure 4. Pseudo-ductile intraply hybrid behaviour.

Further Industrial Relevance of the HiPerDiF technology

ADFRCs manufactured with the HiPerDiF method have been laid-up in a quasi-isotropic configuration demonstrating mechanical performance superior to that of randomly oriented short fibre composite with similar volume fraction [14].

Moreover, intermingled Carbon-Flax hybrids showing promising vibration damping properties have been successfully produced [15,16].

Finally, the HiPerDiF method allows the remanufacturing of reclaimed carbon fibres into a recycled material with one of the best mechanical properties ever reported in the literature [17,6]. It also allows the development of a closed-loop recyclable material [18, 19, 20] and for the quality control and property assurance of reclaimed carbon fibres and recycled composites [21]

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