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VACUUM INFUSION OF NATURAL FIBRE COMPOSITES FOR STRUCTURAL APPLICATIONS

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INTRODUCTION

Numerous methods of manufacturing natural fibre composites have been reported in the literature, including compression moulding, often in conjunction with a hot press. Other forms of composite manufacture include *Vacuum Assisted Resin Transfer Moulding* (VATRM) and the *Seemann Composite Resin Infusion Moulding Process* (SCRIMP). These methods have been reported to produce natural fibre composites with reasonable mechanical properties [1-2]. In this paper, a vacuum infusion rig is described that has been developed to produce consistent quality composite plates for studies into optimising natural fibre composites. The process aims to harness the benefits of vacuum infusion and compression moulding, where vacuum infusion encourages the removal of trapped air in the system and hence void reduction, and additional compression moulding can help to achieve high volume fractions that are otherwise difficult in other processes.

VACUUM INFUSION RIG

The vacuum infusion rig in *Fig.1* has been built with reusability in mind. It is often found that processes such as vacuum bagging lead to excessive wastage of material including plastic sheeting and sealant tape. The vacuum infusion rig has a reusable and washable silicone mould that is sandwiched between a thick aluminium plate and a heavy clear acrylic top face. The clear face allows inspection of the resin progress during fill, which is exceptionally helpful to the operator when controlling the infusion rate using the resin and vacuum control valves. This feature is beneficial as it is observed that very low vacuums can have undesirable effects on the resin, even after extensive degassing. The resin inlet and air outlet are fed into the silicone mould through a channel at each end, and a configuration of peel ply, breather cloth and resin diffuser has been found to produce best fill characteristics. Vacuum to the rig is provided by a vacuum pump via a pressure pot, buffering pressure perturbations, allowing smooth fill of resin through the highly compacted fibre. The high compaction of the natural fibre is achieved through the sandwiching of aluminium and acrylic outer plates using a configuration of bolt fixings and clamping points, thus compressing the mould and its content. The silicone mould is firm enough to allow high fibre compaction without significant deformation, ultimately producing composites with high fibre content.

Fig. 1: left to right. The vacuum infusion rig, mould during infusion, and rig just after fill

THE MATERIALS

The composites plates produced from the vacuum infusion rig are shown in *Fig. 2* and *Fig. 3*. From recent experimentation, the volume fractions of the composite plates manufactured using the vacuum infusion rig can be up to 70 %. The process thus gives significant scope for increasing fibre levels during research studies. Tensile testing of manufactured composites was carried out to ASTM 638-02a and some of the results are shown in *Fig. 4*. The volume fractions for the tested composite materials are 60% +/- 5%. Testing shows Abaca, Flax and Kenaf to have similar failure strengths in the region of 70 MPa, whilst Sisal is higher at 80 MPa and Hemp slightly lower at 60 MPa. All of the composites show significant

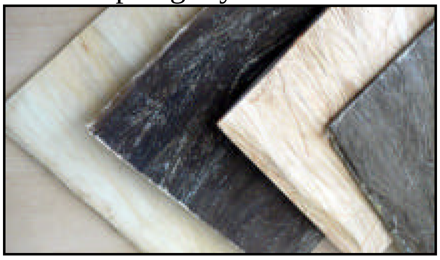

Fig. 2: Composite materials manufactured in plates by vacuum infusion (approx 60% V_f)

Fig. 3: From left to right, Sisal, Flax, Hemp, Abaca and Kenaf composites

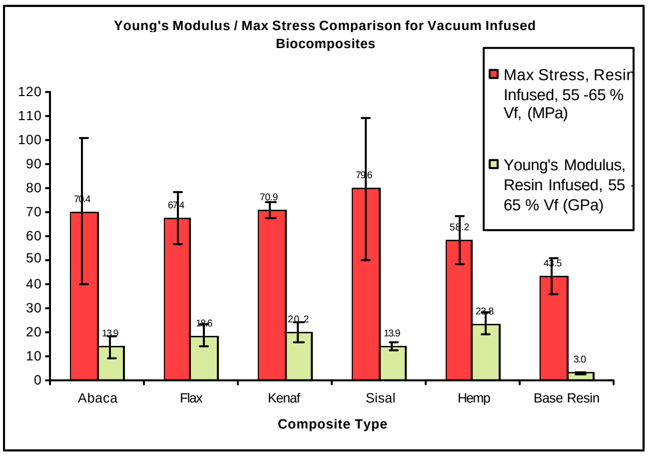

Fig. 4: Young's Modulus/ Maximum stress for vacuum infused biocomposites

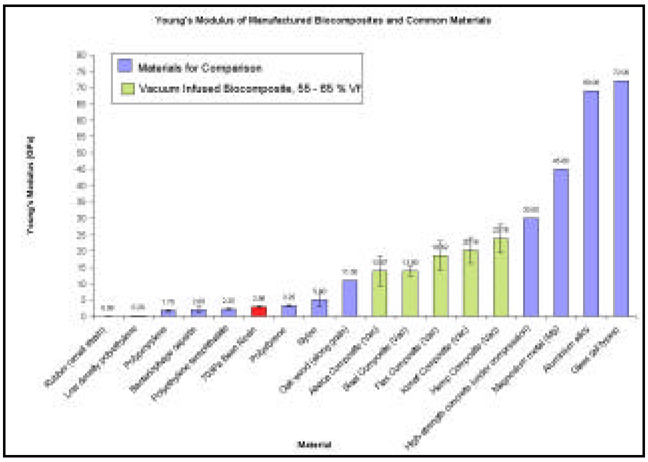

Fig.5: Young's modulus comparison between manufactured composites and other common materials.

improvement of failure strength over the base resin. The improvement of properties over the base resin is however more significant when Young's modulus is considered. Hemp and Kenaf composites show encouraging modulus values at 20.2 and 23.8 GPa respectively, with Flax slightly lower at 18.6 GPa. The composites of Abaca and Sisal exhibit similar properties to each other in the region of 13 GPa. When comparing Young's modulus of these composites to other materials in *Fig. 5,* it can be observed that performance is higher than oak, a quality wood and a cellulose based composite in its own right. This is reasonably encouraging, as it is apparent that the materials may be breaching the property boundaries of glass fibre composites when specific modulus is considered. It is also interesting to note that the composite materials are not showing the same order of mechanical properties in composite form as to the base fibres. This indicates much potential for material development through pre-processing techniques to increase interfacial shear strength between the fibres and matrix. This work is also currently being conducted, and through this it hoped material properties will improve further.

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