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TITLE: FABRICATION OF GNP INFUSED BRAIDED COMPOSITE PIPES USING VACUUM RESIN INFUSION

AUTHOR(S): Othman Alyahya, Rajinth Shanthar, Prasad Potluri, Chamil Abeykoon

AFFILIATION(S):

Department of Materials, Faculty of Science and Engineering, The University of Manchester, Oxford Road, M13 9PL, Manchester, UK

ABSTRACT:

Metallic pipelines have usually been the norm in transporting oil and gas worldwide. However, they are associated with major operational challenges, such as corrosion, in addition to the requirement for significant maintenance work [1]. Non-metallic pipelines might offer a promising solution for the hydrocarbon industry. Their exceptional corrosion resistance could significantly lower maintenance costs [2 - 4]. These composite pipes can be manufactured via techniques such as filament winding and braiding which then can be infused with a polymer resin using Vacuum Resin Infusion (VARI). Nanofillers, which are physical entities which have at least one dimension in the nanometre scale [5], may be mixed with the polymer resin prior to injection. This can be due to several reasons, but for composite pipes in particular the introduction of impermeable particles with high aspect ratios has been found to improve their barrier properties [6], as well as their corrosion resistance [7]. Graphene Nanoplatelets (GNP) are such particles, which increasing the tortuosity of pathways available for molecular transport, as shown in Fig. 1 [8]. Another key application is crack and damage detection, since GNPs convert the matrix into an electrically conductive network. A crack is electrically insulating, and therefore, could be detected with the implementation of a sensing system [9].

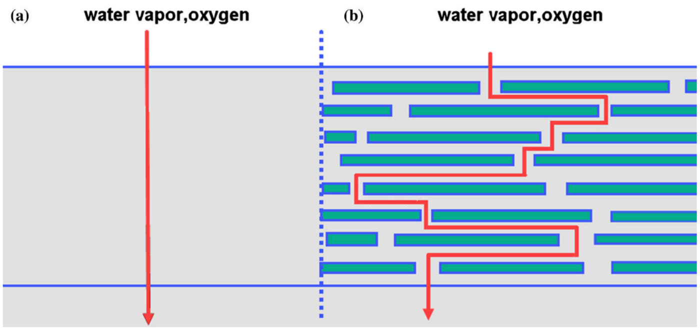

Figure 1: The creation of a tortuous pathway for molecular transport, delaying corrosion (a) Composite without nanofillers (b) Nano composite [6]

This work focuses on the fabrication of nanocomposite pipes via braiding and then use VARI to infuse polymer resins mixed carbon nano-fillers. Then, testing can be performed to investigate the final distribution of nanofillers within the pipe specimen while exploring other related properties such as mechanical strength and leakage resistance. In line with this, the experiments are divided into two stages. The first stage is the fabrication of composite pipes without the addition of nanofillers, using braiding to mount the reinforcing fibres onto a mandrel followed by resin infusion. Braiding has been found to produce pipes with evenly distributed fibres, hence with superior mechanical performance, over the traditional filament winding process [10], [11]. After this process has been fine-tuned and optimal pipe parameters (such as diameter and number of fibre layers) have been determined, the second stage of experiments will commence where the nanofillers will be dispersed in the resin and infused. The final distribution of nanofillers is expected to be inspected using imaging methods. Furthermore, these experimental results will be used to validate the nanofiller transport numerical models, which are also currently being developed in-house. IN2 epoxy infusion resin is used as the matrix material, and Carbon Fibres (CF) are used as the reinforcing material. The nanofillers to be used are GNPs with a nominal size of $10\ \mu m$.

Currently, the first experimental stage has been completed, where composite pipes of 2″ and 4″ diameters having 4, 5 and 6 layers of CF were fabricated (Fig. 2). These were subjected to bending tests, where the 2″ diameter 6-layer specimen was found to adhere to industrial thresholds. Therefore, this 6-layer configuration will be used for the second stage of experiments with nanofiller infusion. The dispersion of GNP within the epoxy resin will be done using mechanical mixing followed by ultrasonication. At first, nano-filler mixed resin will be infused to simple flat composite sheets and the level/quality of distribution of fillers will be observed.

Figure 2: Preparation of the vacuum bag for VARI

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