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Mechanical properties of offshoring polymer composite pipes at various temperatures

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ABSTRACT

Polymer composite pipes can be exposed to the thermomechanical loading due to hot and cold fluid flow, which results in the degradation of their properties. In this paper, effect on mechanical properties of composite pipes under different temperatures ranging from −40 to 80 °C is studied experimentally. The composite pipes consist of glass/epoxy tubes having 86 mm internal diameter and 6.2 mm of thickness with ± 55° glass filament winding, intended for offshoring applications. TEMA TTC machine and split disk are used for uniaxial tensile tests and the thermal aging is considered with the help of SERVONTAN climatic chamber. Thermal aging is carried out on these specimens in climatic chamber for 8 h at different temperatures and then uniaxial test is performed. Experimental results have shown degradation in the mechanical properties of polymer pipes with an increase in the temperature. For pipes at colder temperature, the rigidity of composite increases progressively with the temperature and results in drastic decrease in the displacement at break. Also there is a decrease in the yield stress and an increase in yield strain with an increase in the temperature.

1. Introduction

Recent research advancement has been focused on elucidating the environmental degradation of polymeric composites, such as pipes used in offshore and marine applications. The degradation of polymer composites is provoked by exposure to various environmental factors as variation in temperature, heat, chemical attacks, corrosion and microbes, which results in cracks and embrittlement [1–4]. Polymer composite pipes have been widely used for petroleum and gas transportation because of their low cost of installation & maintenance and excellent chemical, physical & mechanical properties and subjected to different hot and cold temperature [5,6]. Therefore, the mechanical characterization of polymer composite pipes and the understanding of the degradation of their properties with respect to temperature change are essential to develop their potential application in offshore and marine applications.

Several investigations have been conducted in order to determine the mechanical properties of pipes. The ASTM D 2290 and ISO 8521 standard test describe the experimental methodologies to characterize the pipe and allow the use of the classical test techniques developed for flat samples. Ellyin et al. [7] presented an experimental investigation to determine the effect of moisture absorption and exposure to elevated temperature on the mechanical properties of glass fiber reinforced epoxy composite tubes. The tube specimen was a 40.6 mm outer diameter with an inner diameter of 38.1 mm and the fiber volume fraction of 70.8%. The authors observed that for mechanical test, strength and stiffness of the specimens decreased with increasing temperature. Wong et al. [3] studied the mechanical and thermal behaviors of low density polyethylene pipe with variation in thermal exposure. Composite specimens were degraded using thermal ageing at 100 °C for 720, 2400, 6000 and 7200 h and the tensile properties were evaluated with dog-bone shaped specimen. Experimental results imply the existence of transition point from ductile to brittle fracture with a proportional decrease in elongation at break in terms of the thermal exposure time. Soroush et al. [8] studied the elastic behavior of wood–plastic composites at cold temperatures. The authors provide novel methods in material characterization and, in the future, to apply this method to investigate the elastic, hyper-elastic, and viscoelastic mechanical behavior of wood–plastic composites. These composites were used for potential applications in several industries.

Recently, an experimental investigation of temperature dependent mechanical properties of Poly-methyl methacrylate polymer composites was performed by Abdel-Wahab et al. [9] at a range of temperatures 20, 40, 60 and 80 °C below its glass transition point under uniaxial tension

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(a) Pipes for offshoring applications

(b) Tested polymer pipe specimens

Fig. 1. Example of tested polymer samples and their applications.

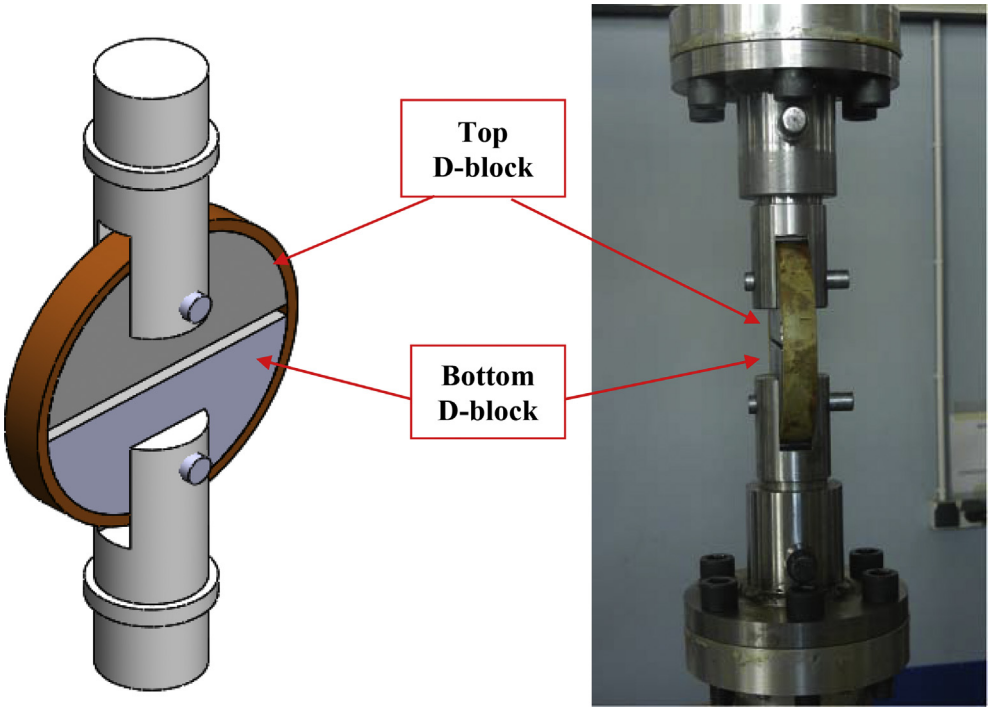

Fig. 2. Split-Disk tensile test apparatus and fixture system of pipe for tensile test.