Technical University of Denmark
DTU Mechanical Engineering
Department of Mechanical Engineering

euspen

Computed Tomography characterization of the Green Fiber Bottle

Prateek Saxena, Giuliano Bissacco

Department of Mechanical Engineering, Technical University of Denmark,
Kgs. Lyngby, DK-2800, Denmark

Introduction

The work carried out in this research aims at identifying suitable ways for thorough characterization of the quality of paper bottles. Industrial X-ray Computed Tomography (XCT) is particularly advantageous in determining the quality of paper bottles and thus correlating it with the production process. The Green Fiber Bottle (GFB) is a freeform geometry consisting of cellulose fibers. Accurate dimensional measurements such as wall thickness of the GFB is not possible using Coordinate Measuring Machines (CMMs). XCT on one hand provides an effective means of measuring wall thickness and on the other hand it also helps in identifying voids in the order of 110 µm at any location in the bottle geometry.

Manufacturing process

Pulp suspension prepared from recycled newsprint pulp of consistency 0.01 was injected in a forming tool using pump. The tool consists of a wired mesh on the inner surface with uniform distribution of holes on the outer surface. Water is removed from fibers by creating a suction pressure from outside of the tool. Tool geometry is thus replicated onto the pulp fibers. The formed product is then transferred to a heated porous tool, where rest of the water is removed and the product is completely dried.

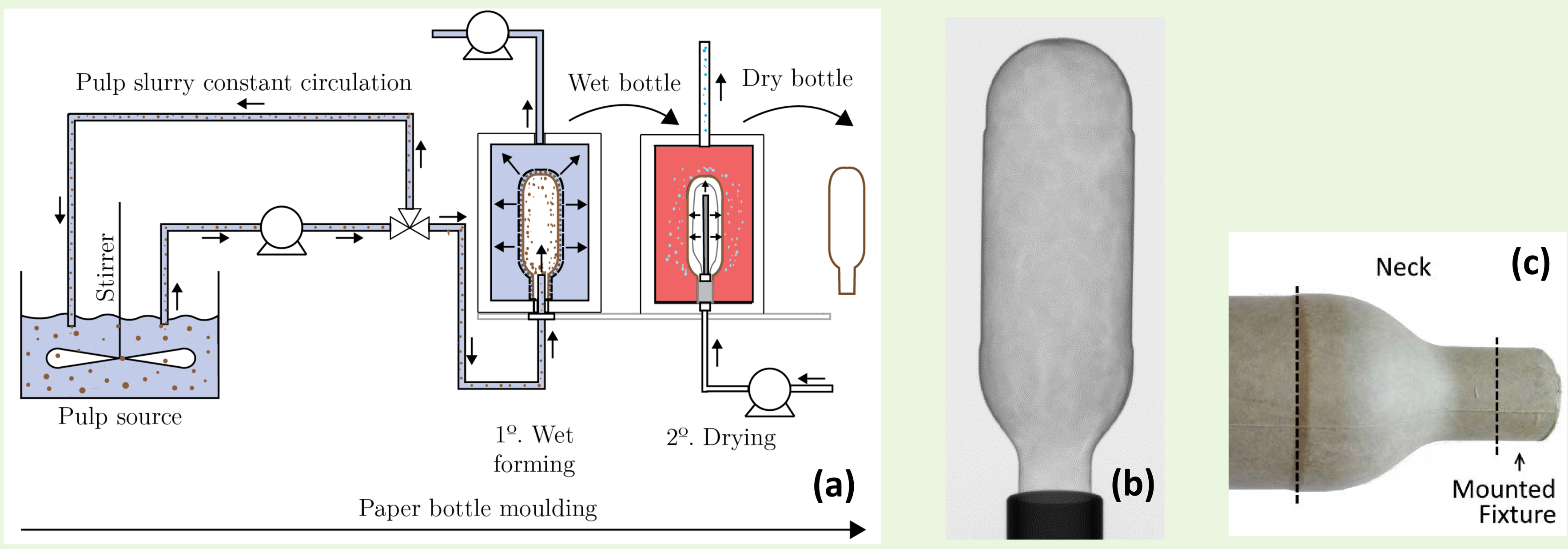


Figure 1: (a) The GFB manufacturing process, (b) XCT scanned image of the GFB and, (c) neck ROI

Process characterization

Porosity analysis

The porosity analysis was helpful in identifying the defects with the resolution of 110µm. A large number of defects in the neck region indicate uneven material distribution in the areas of smooth curvatures. 850µm was the largest defect identified in the bottle geometry. The middle region being cylindrical in shape, experiences uniform material distribution. However presence of a few defects in the bottom region is due to the fact that the bottle is mounted upside down during manufacturing process, thus allowing less pulp material to enter in the bottom section due to gravity.

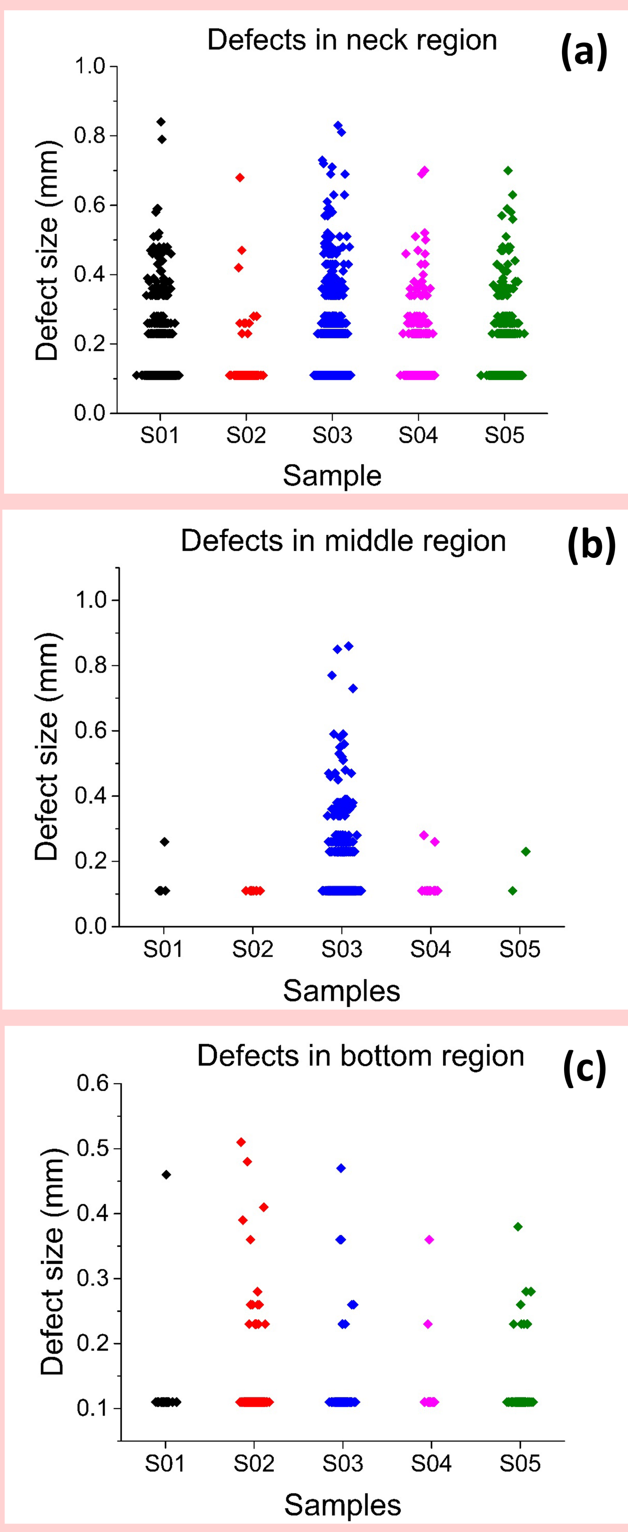
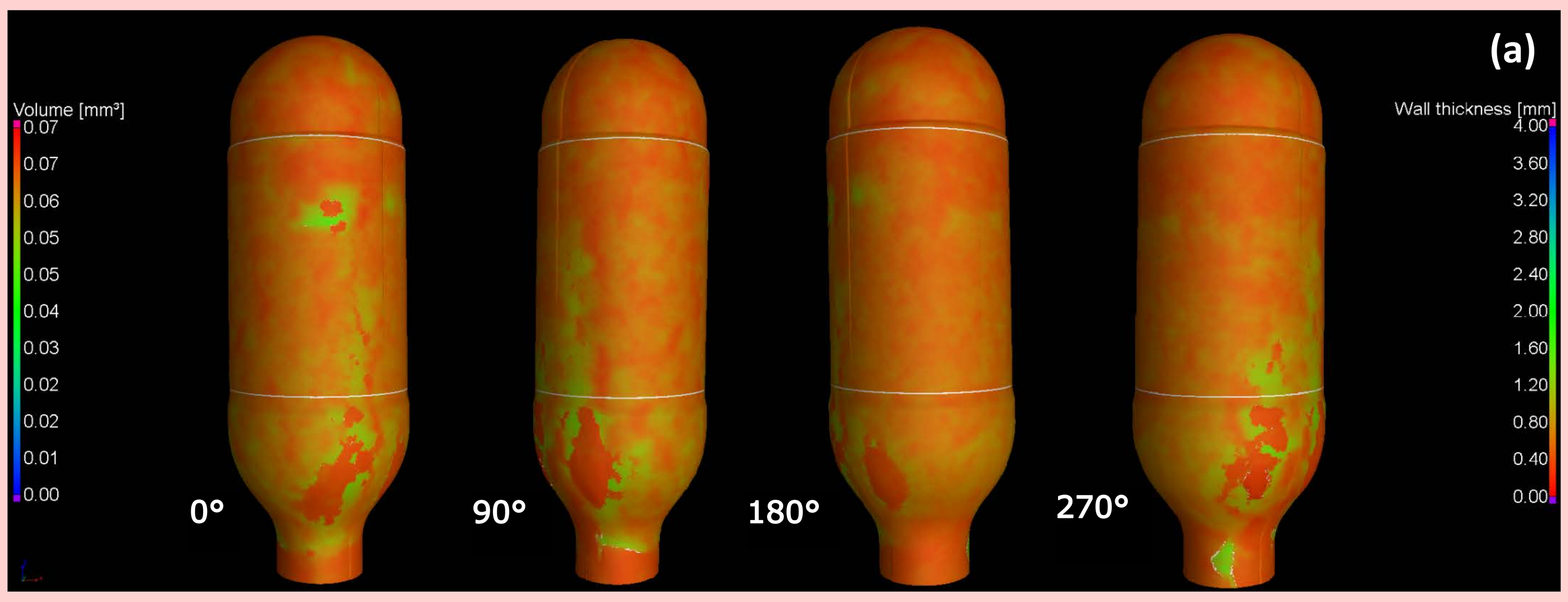


Figure 2: Defect analysis in (a) Neck region, (b) Middle region and (c) Bottom region respectively

Wall thickness analysis



The insert used for fiber compaction is unable to compact pulp in the region of smooth curvatures due to which the neck region experiences higher wall thickness and low localized density.

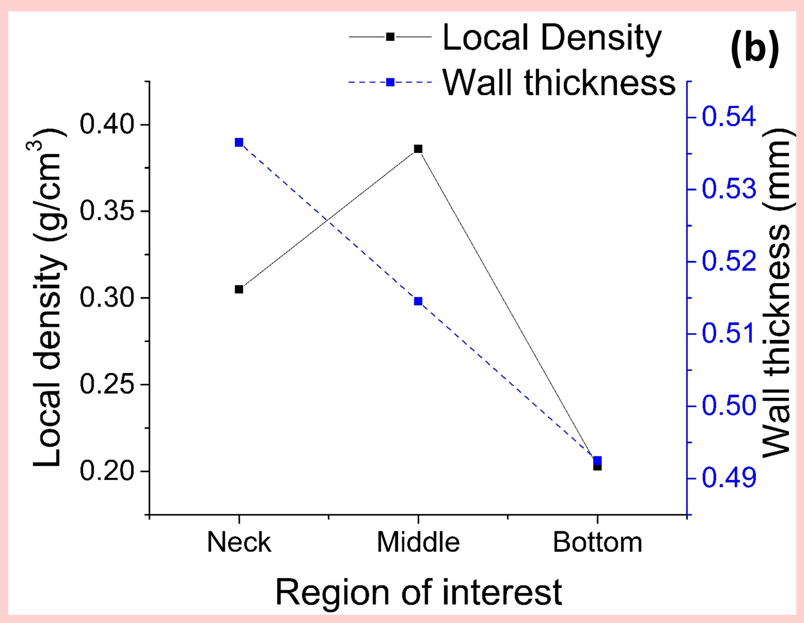


Figure 3: (a) Wall thickness analysis and (b) local density and wall thickness in regions of interest

Conclusions and Future work

Wall thickness in neck section of the bottle was relatively higher compared to rest of the sample, which indicate that the tool is unable to compact pulp effectively in the region of smooth curvatures. Porosity analysis reveals large number of voids present in the neck region, which further indicate the non-uniformity in pulp distribution. Thus, industrial XCT provide a good insight in tool design for manufacturing of paper bottles.

Future work involves development of an efficient and robust tool system for the green fiber bottle manufacturing process.

Acknowledgement

The authors would like to acknowledge the support from Innovations Fund Denmark, EcoXpac and Carlsberg group for all their help and support in carrying out this work.