Research Diary

Buckling studies in 3D printed cylindrical shells

Dr Gangadharan Raju,
Department of Mechanical and Aerospace Engineering

KID: 20220109

Thin cylindrical shell structures are widely used in aerospace structures, but they are prone to buckling and structural collapse. So, it is of utmost importance to consider buckling as one of the critical criteria for designing cylindrical shells to prevent a catastrophic failure. Most of the research in this area has been focused on metallic or composite shells fabricated using conventional techniques. As a thin shell's structural stability is very sensitive to geometric imperfections, its response in the presence of imperfections requires intense experimental and numerical studies. This requires fabricating shells with controlled geometric variations which are possible using 3D printing. Further, testing on real size cylindrical structures is challenging and expensive which can be addressed by studying the buckling and post-buckling response in scaled-down models. A scaled cylindrical shell made of Thermoplastic Polyurethane (TPU) is fabricated using an 'Ultimaker S5 3D printer Pro Bundle', which is available with the 'iTIC'. This shell is tested under axial compression using an MTS system and its buckling response is captured using a multi-Digital Image Correlation (DIC) technique. The DIC results would aid in the development of robust numerical models for designing cylindrical structures as shown in **Figure 2**.

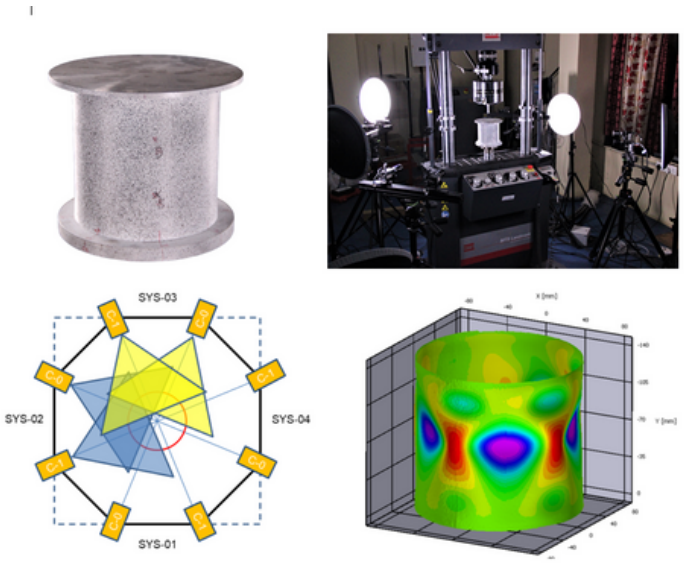

Figure 2: Experimental setup to capture the buckling deformation of the cylindrical shell

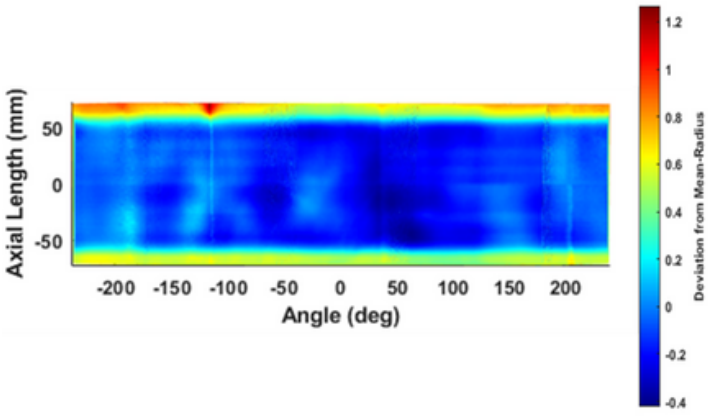

Figure 3: Cylindrical imperfection measured using DIC

Also, the geometrical imperfections in the shell are captured using the DIC and can be used for high fidelity numerical studies as shown in **Figure 3**. A short fiber composite cylindrical shell with a dimple-driven imperfection was fabricated using 'A mark-forged Mark two' 3D printer as shown in **Figure 4** which is available with the MAE department.

In this work, we aim to understand the stability and collapse behavior of cylindrical shells with structural discontinuities like cut-outs and complex stiffener geometries. These studies have a direct application in the aerospace industry and it is being carried out in collaboration with Research Centre Imarat (RCI)-DRDO

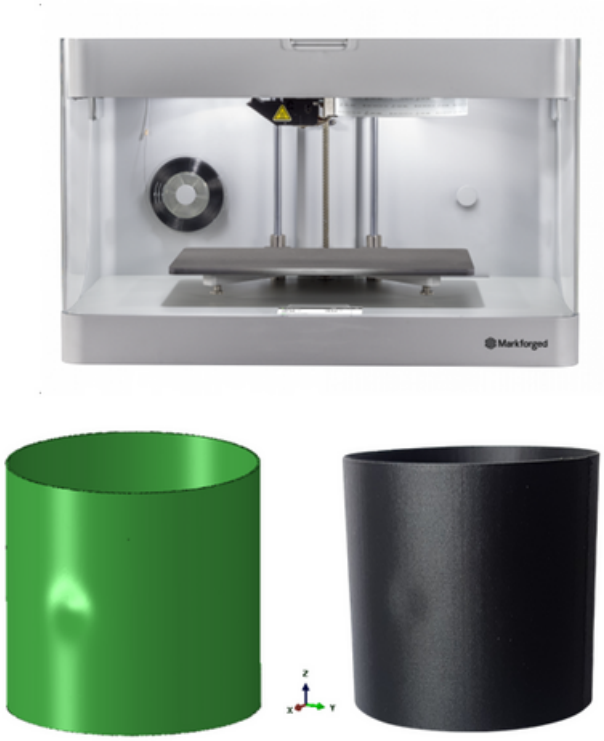

Figure 4: Markforged Mark Two 3D printer