HyVR: Hybrid Vacuum-Robotic forming

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Vacuum forming processes offer a rapid and low cost method to manufacture large components, omitting the need for an expensive matched two-part mould. However the atmospheric pressure driving the forming can sometimes fail to overcome frictional and bending forces, preventing material being drawn into some concave areas. This project presents a hybrid vacuum-robotic process (HyVR) which aims to tackle this issue. The vacuum forms the majority of the component while robotic layup techniques apply localised forces in difficult areas. This has been successfully demonstrated on components with multiple deep drawn concave features which are not possible with vacuum forming alone. In addition to assisting forming, the robot can dictate the ply movement, defining where the ply is drawn in from and where it remains in place.
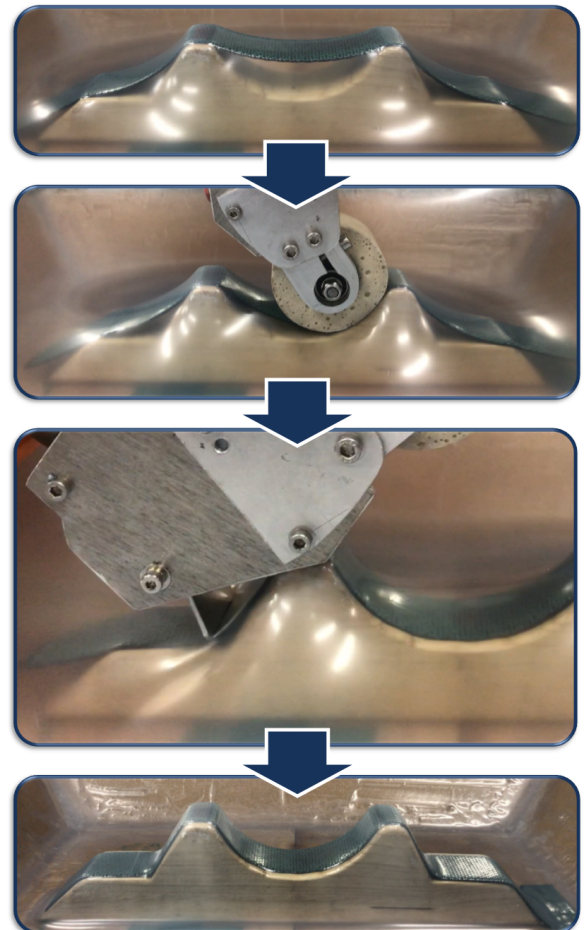
Example HyVR process:

Step 1: Vacuum only – Concave regions fail to form. To assist forming the vacuum is dropped to 50%, reducing friction between the ply and mould.

Step 2: A roller, actuated by a robotic arm, applies additional pressure to the concave region. This draws material in from the left hand side of the ply to fully form the concave region.

Step 3: A pair of end effectors are used to consolidate the corners. A rubber pad 'locks' the ply onto the surface, preventing the central region being pulled off the mould. A second end effector then presses the ply into the corner.

= Ply movement

= Air pressure

End effector

Rubber pad 'locks' ply in position
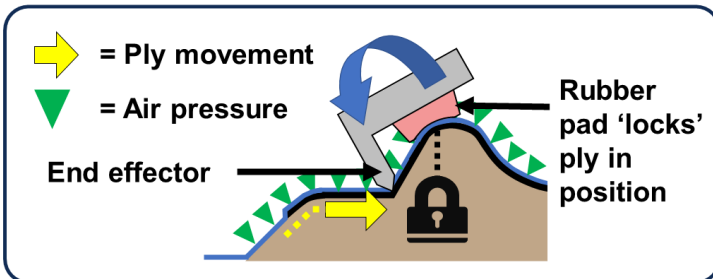
Step 4: Once both the concave regions are completed, a full vacuum is applied, forming the remainder of the ply

Future work: Recent trials have shown the HyVR process can produce double curvature shapes, generating in-plane 'shear' within the woven reinforcement as robot applies pressure to concave regions.