Hele-shaw cell design for experimental analysis of adhesive flow

P.M.S Almeida | A Akhavan-Safar (INEGI, Portugal) | RJC Carbas | EAS Marques | J Hrachova | H Leenders | Lucas F.M. da Silva

1. Introduction

Adhesive flow behavior during compression plays a key role in ensuring strong, reliable bonds in engineering applications. This study introduces a custom-designed Hele-Shaw cell integrated into a Universal Testing Machine (UTM) to investigate the squeeze flow of adhesives between different substrates. The device, machined from high-strength aluminum 7075, allows precise compression control and real-time top-view imaging. Its modular design supports various substrate materials, enabling detailed experiments for model validation and process optimization in industrial bonding.

2. Design

The device is compact, lightweight, and modular, ensuring quick assembly, easy cleaning, and compatibility with various substrate materials.

The structure consists of a rigid bottom plate with alignment pins and guide rod mounts, four vertical guide rods for precise motion, and a top plate with a central cutout for substrate mounting and optical access. Load arms connect the top plate to a top support, which also provides space for camera positioning. A connector flange secures the setup to the UTM.

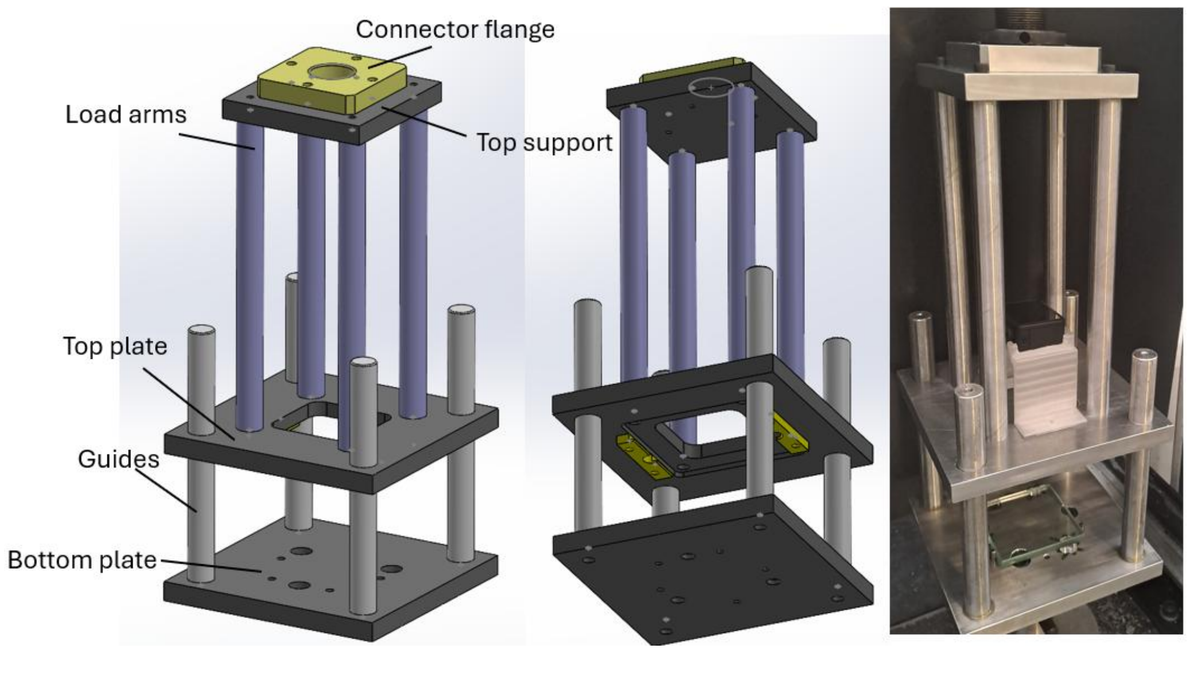

Figure 1. 3D model of the Hele-Shaw cell and real device mounted on UTM.

3. Structural analysis

A static linear elastic simulation was performed in SolidWorks, applying a 15 kN vertical load. Based on the observed stress distributions and the comparative results for mass and yield usage, steel was considerably heavier and operated at a higher fraction of its yield strength. Considering the reduced mass, and superior strength-to-weight ratio, Aluminum 7075-T6 was chosen for the final Hele-Shaw cell design.

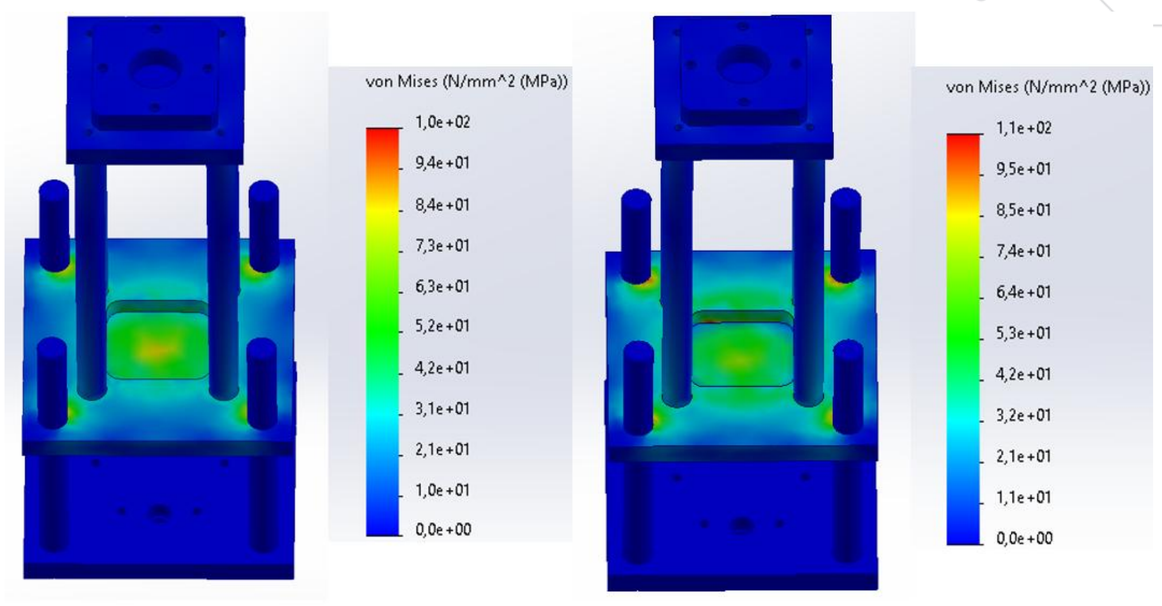

Figure 2. Stress distribution.

Mass and yield for aluminium and steel.

	Aluminium	Steel
Mass(kg)	4.8	13.2
Yield(%)	19.8	53

4. Results

Experimental tests were conducted to evaluate the reaction force as a function of adhesive thickness during the squeeze flow process. The results showed consistent trends across repeated trials, indicating good repeatability of the measurements and reliability of the experimental setup.

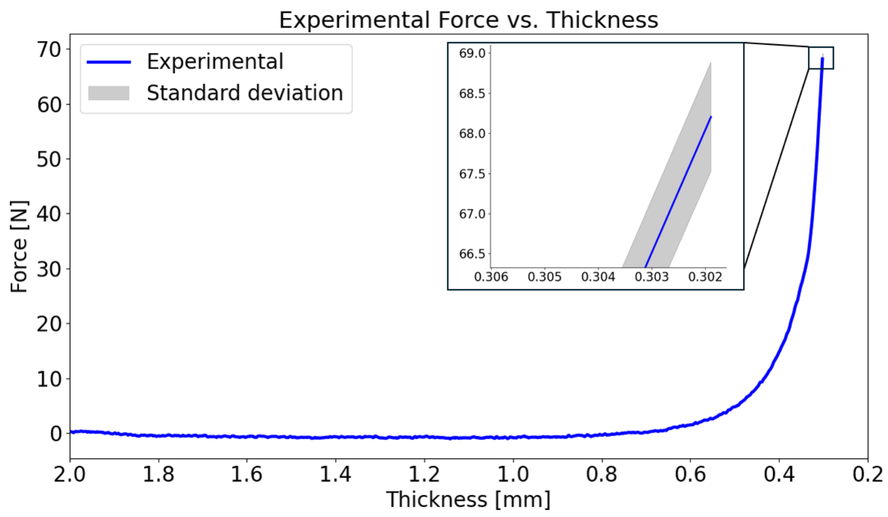

Figure 3. Measured force as a function of adhesive thickness.

5. Conclusions

- Custom Hele-Shaw cell enables controlled adhesive squeeze flow experiments.
- Designed for mechanical safety under high compressive loads.
- Demonstrated repeatable and reliable performance in trials.