Design, validation, and manufacturing insights of a custom cyclic creep testing station for pressure-sensitive adhesives

BD Simões (INEGI, Portugal) | EMD Fernandes | EAS Marques |

RJC Carbas | S Maul | P Stihler |P Weißgraeber| Lucas F.M. da Silva

Introduction

The characterization of creep behaviour enables assessment of structural durability and long-term performance. This work presents a compact cyclic creep testing station for single lap joints (SLJs) using pressure sensitive adhesives (PSAs), capable of operating between -40 °C and 90 °C within a thermal chamber. The device applies cyclic loads via a periodic weight-support mechanism and is validated against a servo-hydraulic testing machine.

Design

Design requirements

- **Max displacement**: ~13 mm | Max load: ~80 N
- **Max displacement**: ~13 mm | Max load: ~80 N
- **Compact** design **to fit inside thermal chamber**
- **Operating ran**ge: –40 °C to +90 °C
- All components rated for full temperature range

Cyclic creep machine design

The cyclic creep machine (Figure 1) features a vertical tower with a lever arrangement for load multiplication, constructed from a lightweight Bosch Rexroth 50×50 mm² aluminium profile.

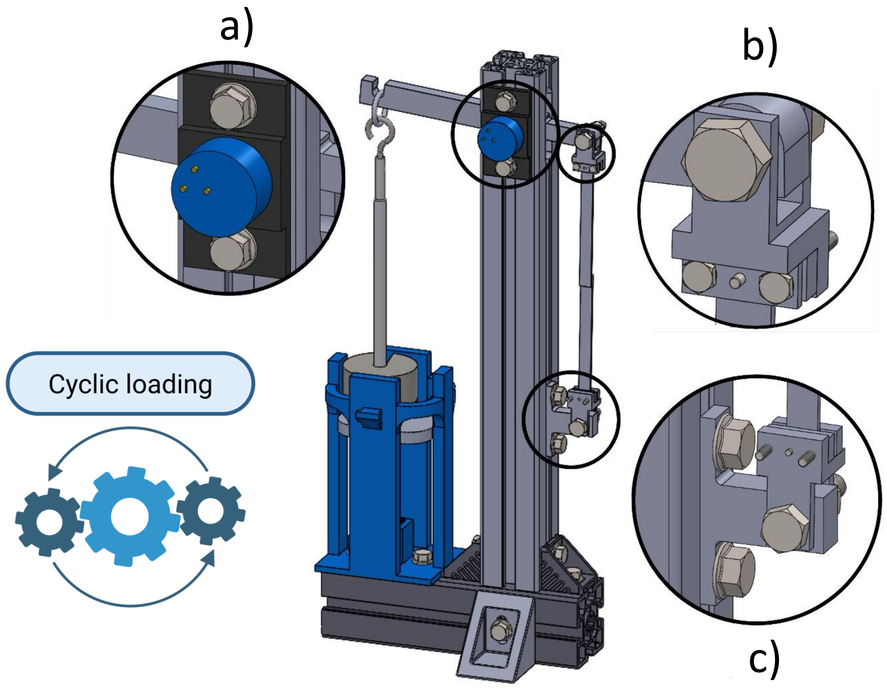

Figure 1– CAD model of the cyclic creep testing machine: a) potentiometer and lever assembly for load application; b) upper specimen grip; c) lower specimen grip.

Joint geometries

Substrates of PMMA and aluminium alloy (6000 series) were tested with two acrylic PSAs: a transparent (Adhesive 1) and a foam (Adhesive 2) variant. Quasi-static SLJ (Figure 2) tests at 1 mm/min yielded failure loads of 78.22 ± 6.75 N and 40.35 ± 1.17 N, respectively.

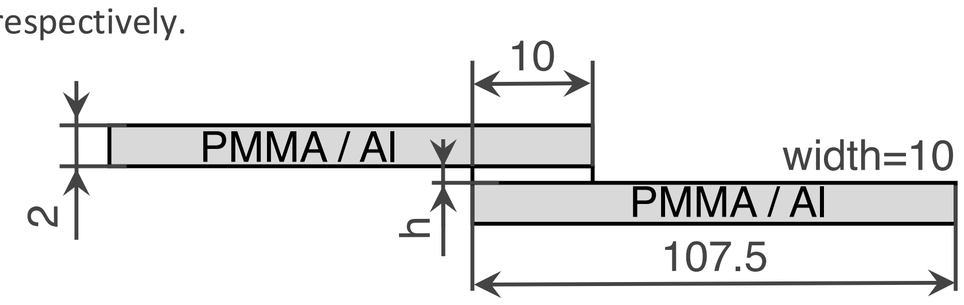

Figure 2 – SLJ geometry (dimensions in mm): overlap length 10 mm, substrate length 107.5 mm, substrate thickness 2 mm, width 10 mm.

Results

Testing setup

Reference tests used a servo-hydraulic machine with a 0.04 Hz trapezoidal waveform, with DIC applied to photographs taken at each load/unload phase. The designed machine setup included a power supply, data acquisition device, and a dedicated driver for the cyclic mechanism.

Experimental results

Validation was performed by comparing cyclic creep curves from both machines. Figures 3 and 4 shows results for Adhesive 1 and 2 on acrylic and aluminium substrates under two load levels (40% and 60% load level) at room temperature and 55°C temperature, respectively.

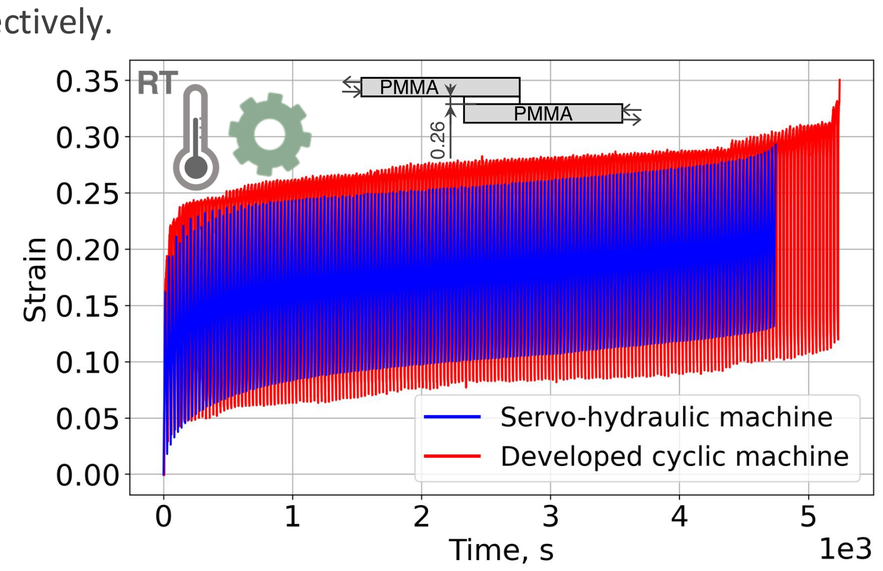

Figure 3 – Cyclic creep curves for Adhesive 1 on PMMA substrates at room temperature.

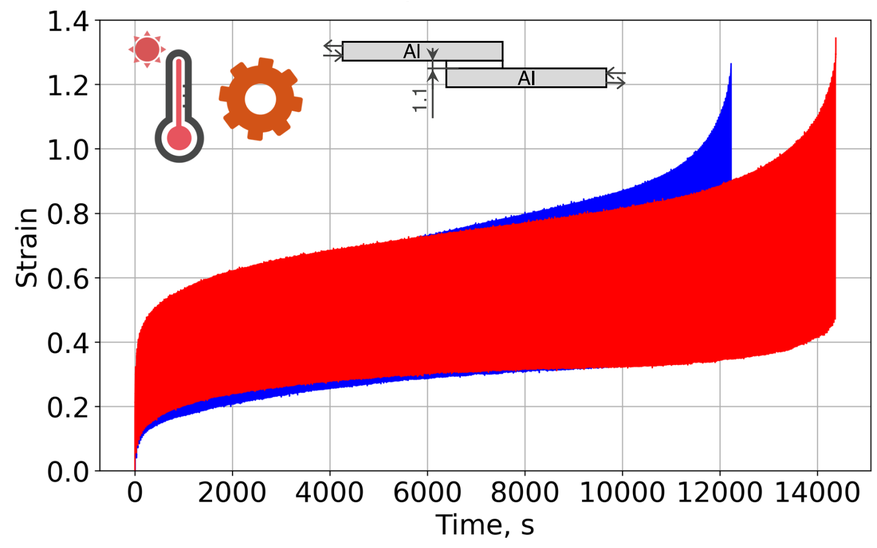

Figure 4 – Cyclic creep curves for Adhesive 2 on aluminium substrates at 55°C.

Highlights & conclusions

✓ Cyclic creep machine successfully validated against servo-hydraulic reference for two adhesives and substrates.

✓ Design allows adjustable joint length, frequency, and duty cycle for flexible testing conditions.

✓ Experimental results confirm reliable cyclic creep capture across different substrates and temperatures.

3RD INTERNATIONAL CONFERENCE ON ENGINEERING MANUFACTURE