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Investigations on Irreversible Deformation Properties of Leather

INTRODUCTION

- Leather material is stressed through application by mechanical load and environmental heat and moisture impact
- Relevant deformations in leather: unaesthetic appearance, reduction of comfortability induced by resulting waves and wrinkles
- Premature failure of trim material, customer complaints associated with high costs to the industry
- Limitation: quantification of leather's deformation properties by means of established standardised test methods not sufficient

OBJECTIVES

- Development of new testing approach: determination of elongation and relaxation properties under compression stress
- Loading scenarios with practical relevance to upholstery and automotive interior trim applications
- Consideration of different types of design-engineered material combinations

TESTING INSTRUMENT

- New designed testing instrument (Figure 1) featuring automatic operating units for controlling and data recording:
  - Continuous detection of force-deformation curves (Figure 2)
- Multiple variations of load and microclimatic condition´s impact adjustable:
  - $F_{max.}$ of 1000 N
  - Two types of pistons (50 and 200 mm)
  - Integrated heating element for external heat treatment
  - Special designed fixation frame for sample clamping (effective test area (400 x 400) mm)
  - Wide range of experimental setups

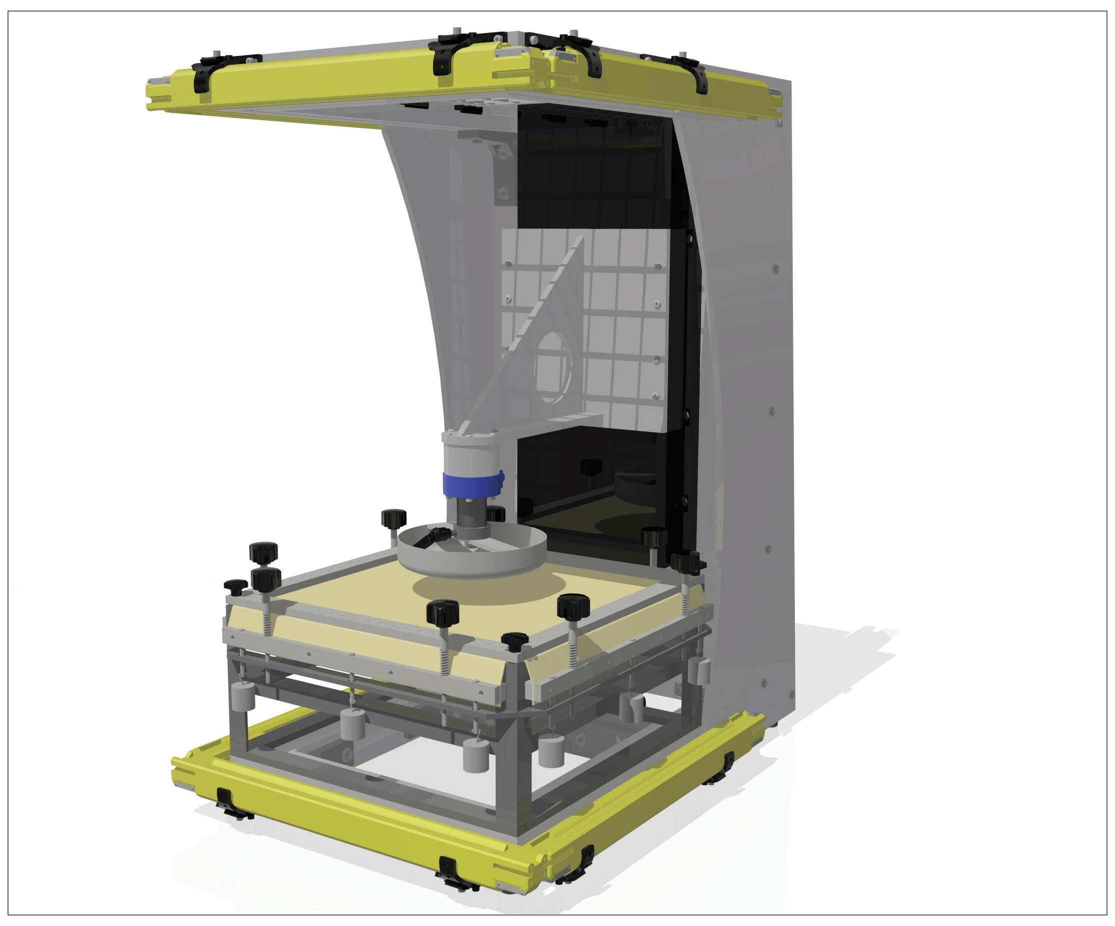

Figure 1: Scheme of testing instrument for determining leather's elongation and relaxation properties (© ZINS Ziegler-Instruments GmbH).[1]

METHODOLOGY

- Analyses of various types of upholstery leather
- Testing of experimental arrangements with and without cushioning
- Observation of thermal and/or microclimatic effects:
  - Temperatures of 23, 50 and 70 °C
  - Moistening: by placing defined moistened cotton cloth on leather's surface
- Types of mechanical loading scenarios applied:
  - [A] Statical
    single long-lasted loading, followed by longer release phase: 200 mm piston, static 500 N load, 1 h stress, 3 hrs release, 5 repetition
  - [B] Periodical
    repetitive cyclic loading: 200 mm piston, alternating 500 N load/zero load, 60 s each, 1 h stress, 3 hrs release, 5 repetition
  - [C] Impulsive
    impact loading, single cycle with maximum force amplitude: 50 mm piston, static 500 N, 1 h stress, 3 hrs release, 5 repetition
- Extracting leather sample specific parameters from force-deformation curves for qualification of leather's elongation and relaxation properties (Figure 2):
  - Visco-elastic deformation of stress phase (ε_1)
  - Elastic deformation (ε_2), visco-elastic deformation (ε_3) and permanent deformation (ε_4) of release phase
  - Parameter ε_4 represents irreversible deformation properties

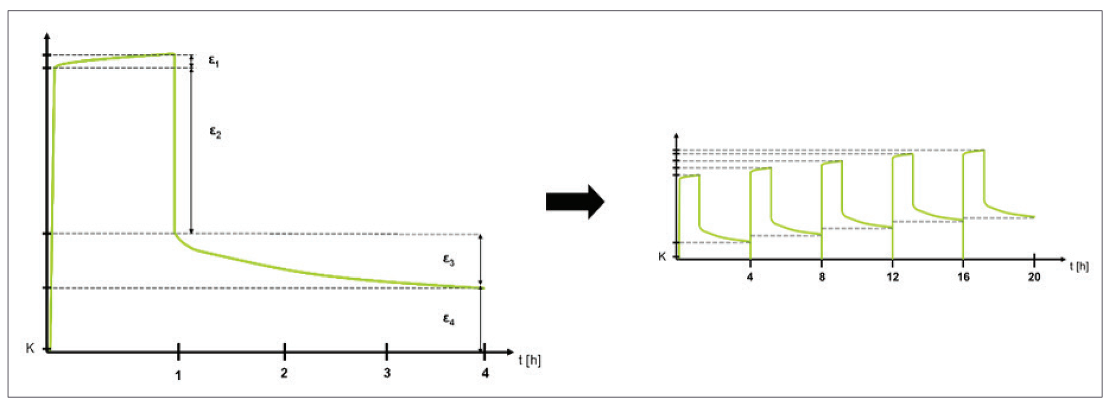

Figure 2: Parameters for determination of elongation and relaxation properties of leather: single load cycle (left), sequence of five load cycles (right).

RESULTS & DISCUSSION

- Statical [A] and periodical [B] loading exhibit almost similar results on irreversible leather deformations, significant differences by impulsive loading [C] (Figure 3)

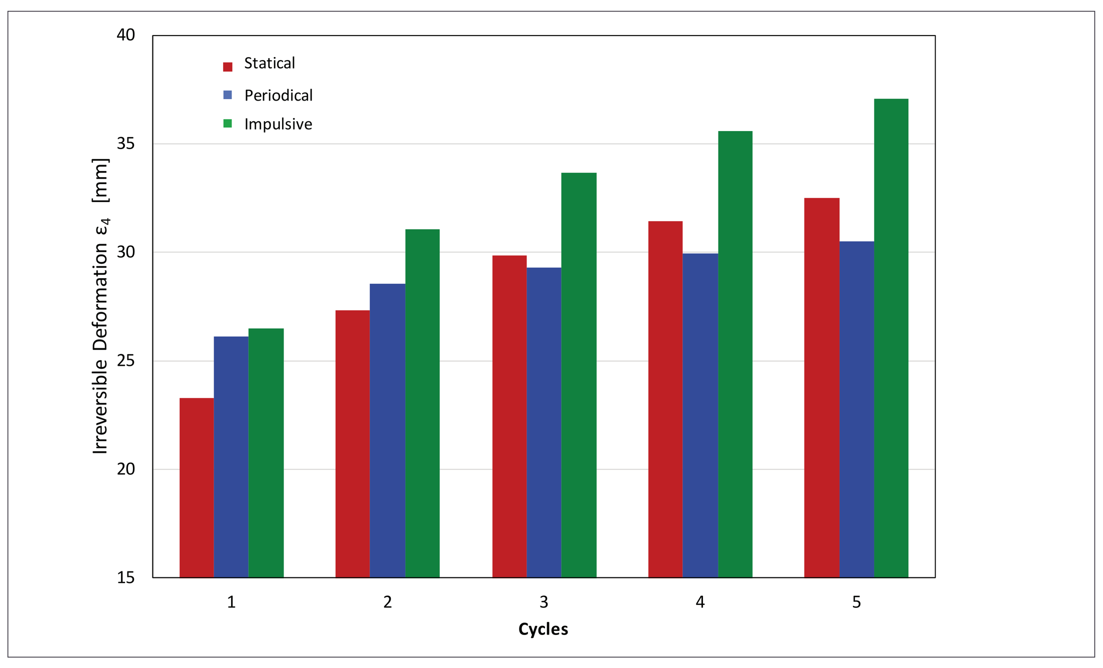

Figure 3: Statical, periodical and impulsive loading results for comparison.

- Proceeding number of test cycles: increasing proportion of permanent deformation (ε_4) accompanied by decreasing proportions of ε_2 and ε_3 (= increasing material fatigue phenomena)
- Cushioned material arrangement with PUR foam and polyester non-woven: markedly reduced irreversible deformation (ε_4) of leather, domination of elastic PUR foam properties (Figure 4)
- Temperature influence on ε_4 of leather: by trend only, slightly decreasing irreversible deformation by temperature increase of 23, 50 and 70 °C
- Moisture influence on ε_4 of leather: significant, increasing irreversible deformation by increasing moisture level

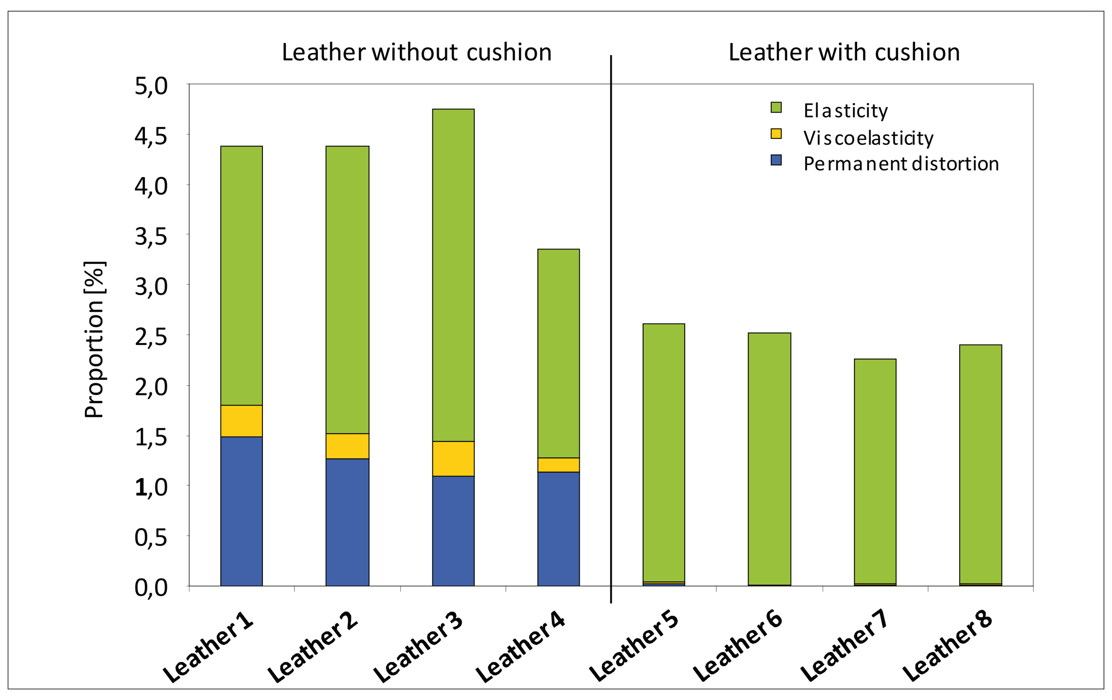

Figure 4: Comparison on proportions of elastic, viscoelastic and irreversible deformation properties of pure leather and leather cushioned with PUR foam, applying statical load type [A].

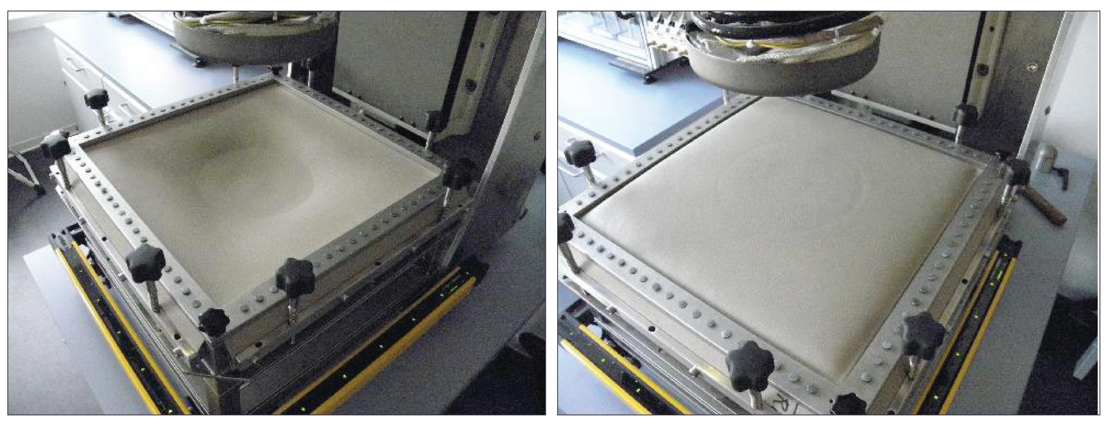

Figure 5: Images of clamp-fixed leather samples after five test cycles without (left) and with PUR foam cushion (right).

CONCLUSIONS

- New test instrument and test procedure for investigation on elongation and relaxation properties of leather
- Analyses of various types of upholstery leather considering different types of loading scenarios, varied padding arrangements as well as thermal and microclimatic loadings
- Specific parameters of elasticity, viscoelasticity as well as permanent distortion extracted for leather qualification
- Compared to standardised mechanical test procedures a method with more relevance to the application of leather testing could be established

REFERENCES

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