Investigation of the applicability of finite element techniques for the simulation of Shore hardness tests

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1 Introduction

Shore hardness is widely used for characterizing materials, while the appropriate scale for elastomers and rubber-like materials is Shore A. Accurate results require specimens that meet strict geometric standards, but these are often impractical. Therefore, this thesis set out to answer the following key question: *Is it possible to eliminate the distortion effect when rquirements does not meet the standard minimum?*

2 Gathering results & simulation

To gather the neccessary data, an automated simulation workflow was developed, as shown in Figure 1.

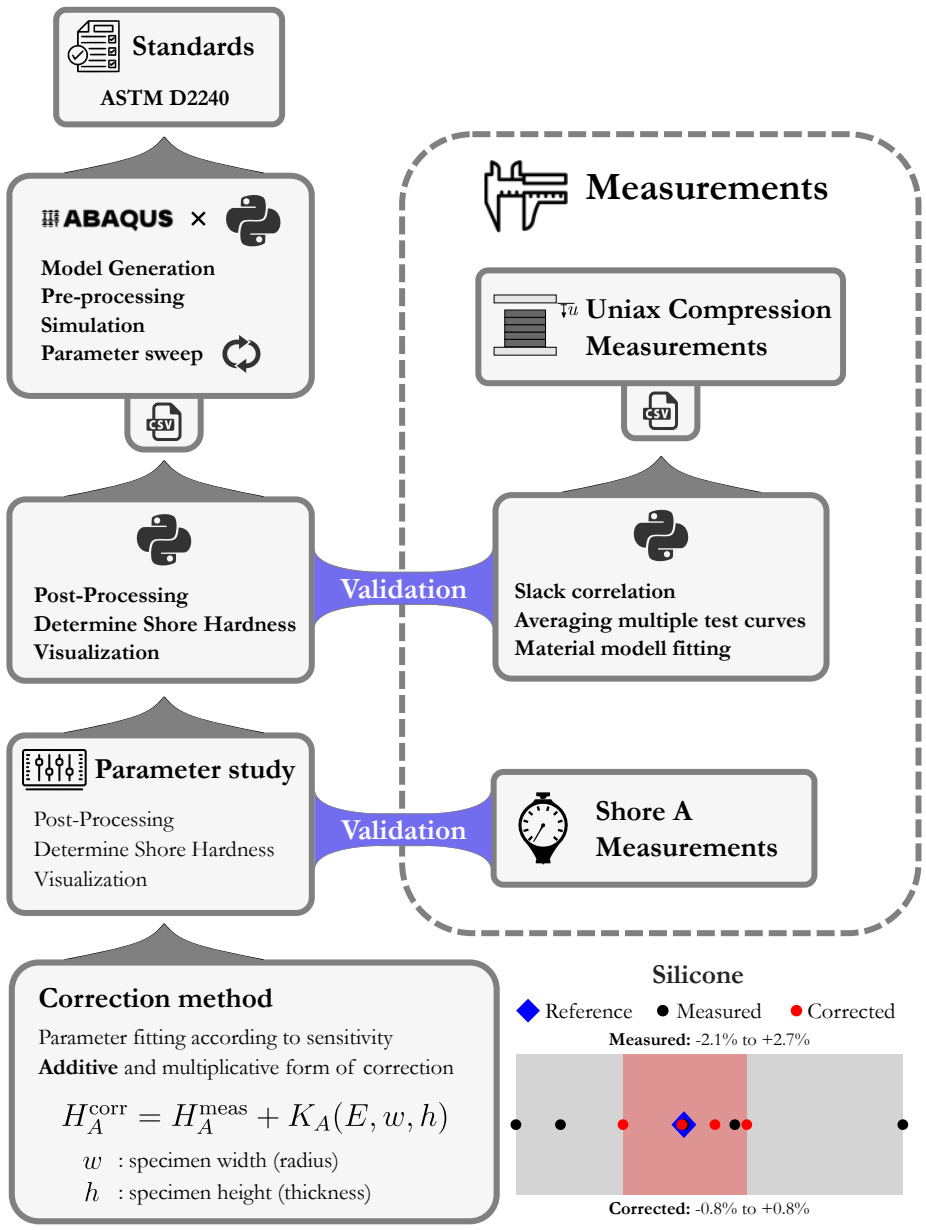

Figure 1: Workflow of the thesis structure and simulation

During automation, the first challenge was to extract Shore A hardness from simulation. This was done by comparing the simulated force–displacement curve to the calibrated spring response of the durometer knowed from standards and user manuals as

$$F_S = 0.55 + 0.075 H_A.$$

By finding the intersection point between the simulation results and the calibrated spring force, the corresponding Shore A value is determined as Figure 2 shows.

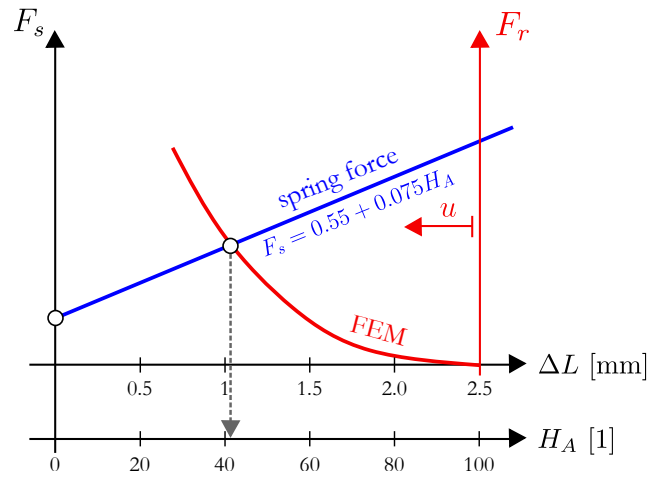

Figure 2: Shore A hardness from FE-simulation

3 Results

As for results, i've investigated every geometric parameter and some material parameter and tried many types of additive or muliplicative correction methods. The most efficient correction method achieving over 90% error reduction and formulated as

$$K_A = C_1 \cdot E + C_2 \cdot \tfrac{1}{w} + C_3 \cdot \tfrac{1}{h} + \log(E)\left(C_4 + C_5 \cdot \tfrac{1}{h} + C_6 \cdot \tfrac{1}{w}\right) + C_7,$$

$$H_A^{\text{corr}} = H_A^{\text{meas}} + K_A(E, w, h).$$

With this correction method the results are more aligned with the so called reference result as Figure 3 shows

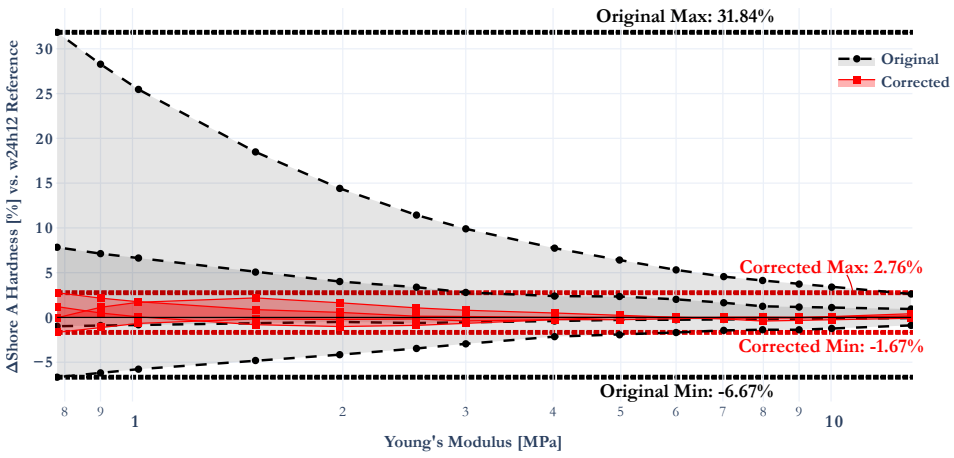

Figure 3: Deviation from the reference after correction

4 Summary

The developed correction method enables reliable Shore A testing even when standard specimen dimensions cannot be met. The method was based on automated FE simulations and validated experimentally, achieving over 90% error reduction in the 20–80 Shore A range.

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