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# ELECTROMAGNETIC PEENING: A NOVEL WAY TO TREAT METALLIC PARTS

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## INTRODUCTION

Surface compression of metal parts, creating residual stresses and surface hardening, is a popular industrial surface treatment. It makes more performant and cheaper parts (hardness, lifetime, ...).

Classical shot peening[1] is a common process to induce surface compression. This technique is well known and widely used however it suffers several drawbacks. The treated depth is way less than a millimetre, the process is relatively hard to tune, leaves a rough surface and might bring pollution problems. On the contrary, electromagnetic peening can reach much further depths, up to 15mm[2]. Furthermore, this proposed process is easy to simulate and to predict, and does not require contact with the surface.

To achieve this treatment, a high magnetic field, typically around 60 Tesla, must be applied to the test sample. An inductor that is able to create such field has been designed, with the help of finite element modelling. The inductor shall withstand high currents (several tens of kilo-amperes), high voltage (several kilo-volts) and high forces from the coils that repel each other.

## METHODOLOGY

The presented results are from the treatment of an AA6061 aluminium rod ( $\varnothing 10\text{mm}$ ):

- The treatment consist of a 165kA current (generating approx. 45T) pulsed through a single turn coil, wrapped around the sample.
- After this, we performed a tensile test on the whole sample, while monitoring the strain along the main axis (using DIC, Digital Image Correlation).

If the treatment succeeds, we should see a region of the sample significantly resisting the elongation.

## TREATMENT SETUP

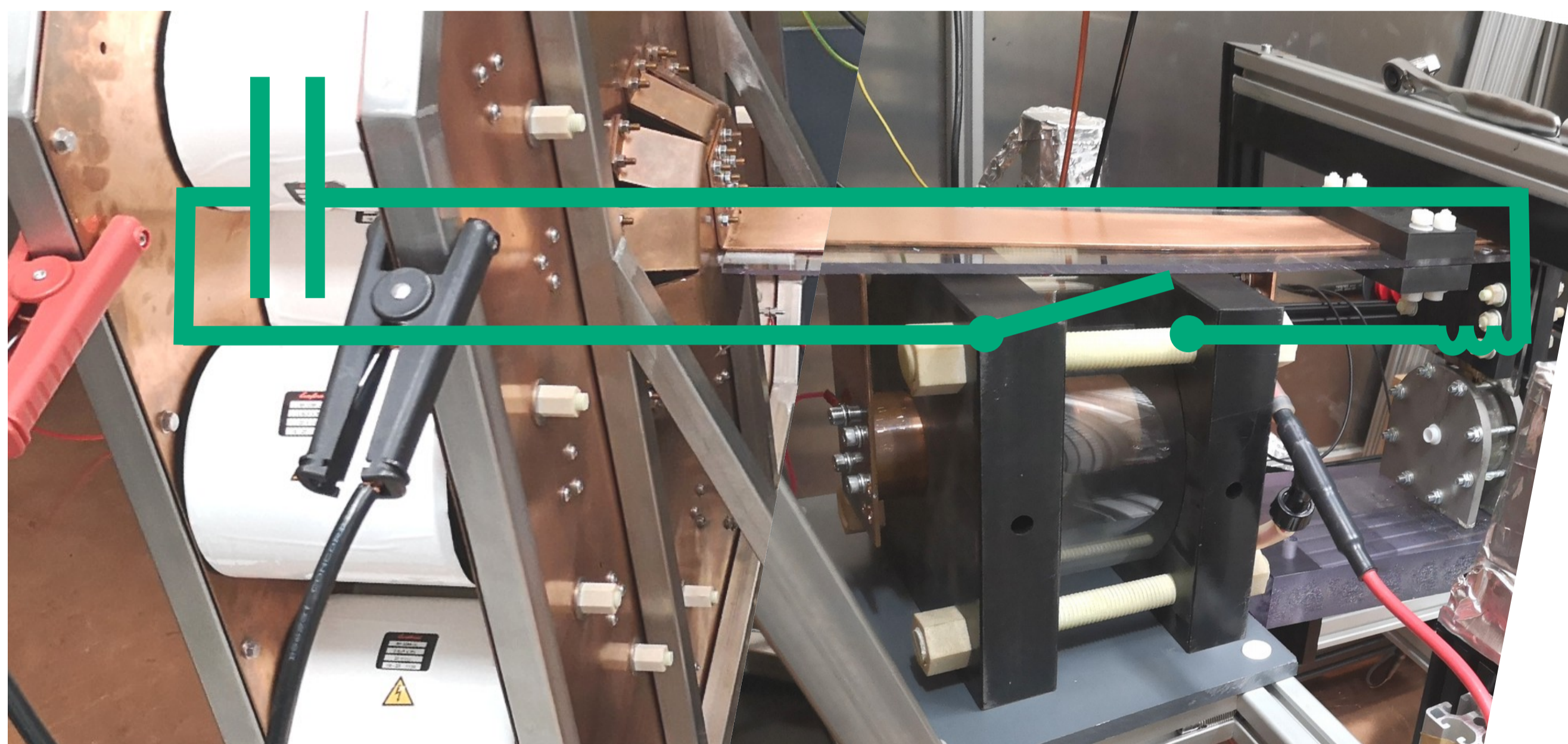


Figure 1: Treatment setup. Showing the capacitors (left), the spark-gap (center), and the inductor (right).

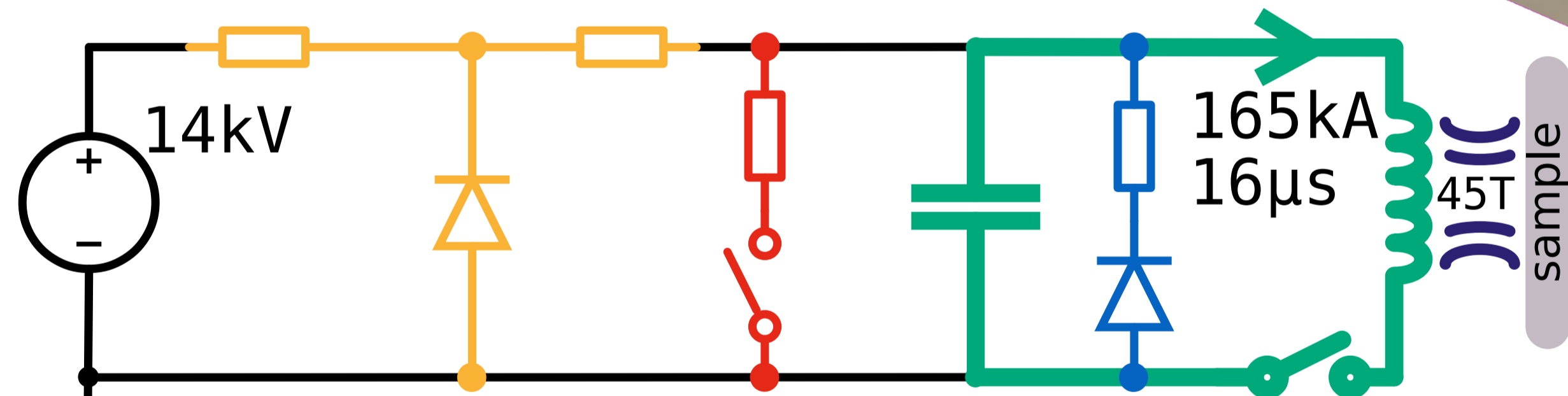


Figure 2: The electric circuit of the treatment setup.

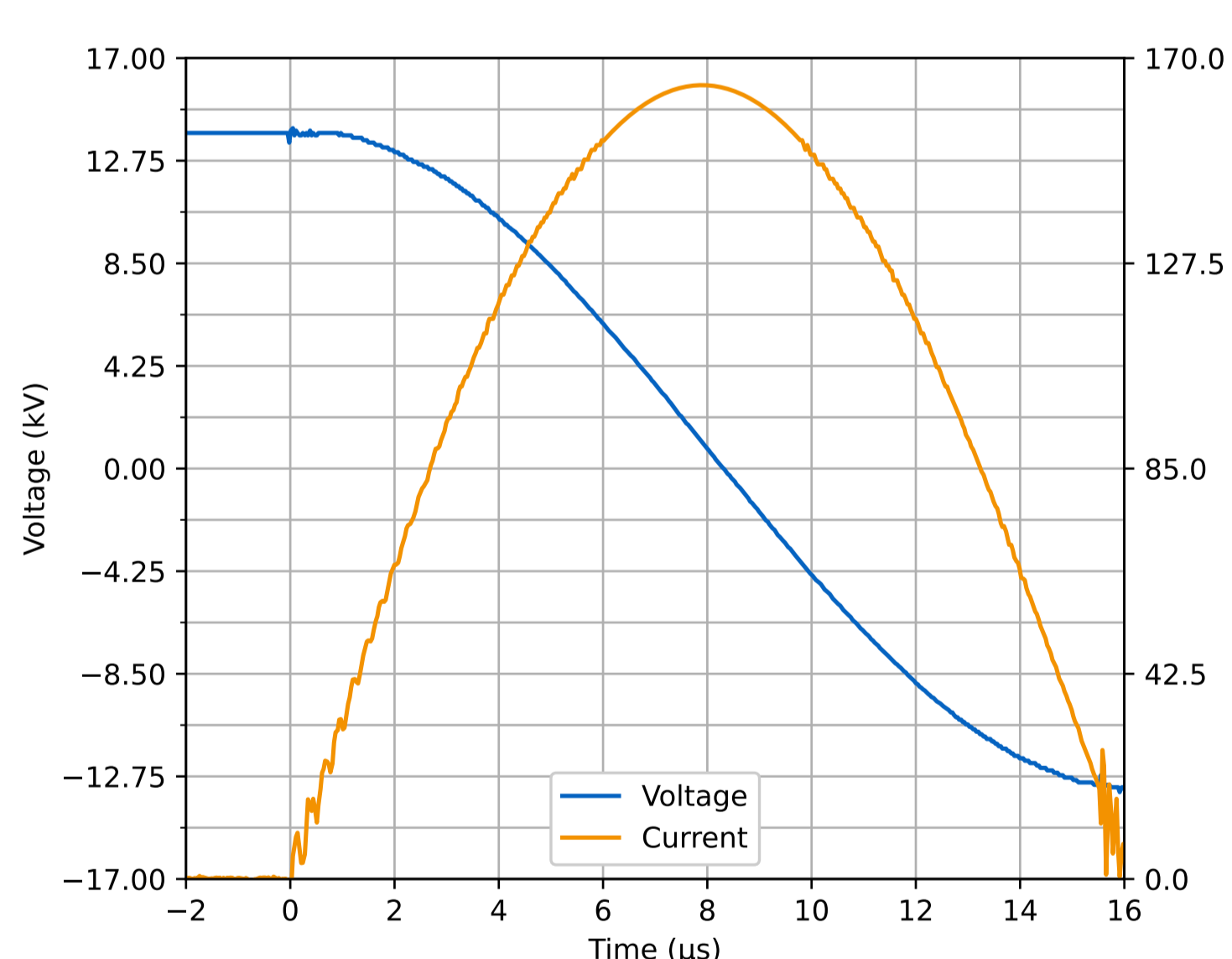


Figure 4: Voltage and current seen by the inductor during the treatment.

Figure 3: The sample surrounded by the inductor.

## SIMULATION & TENSILE TEST

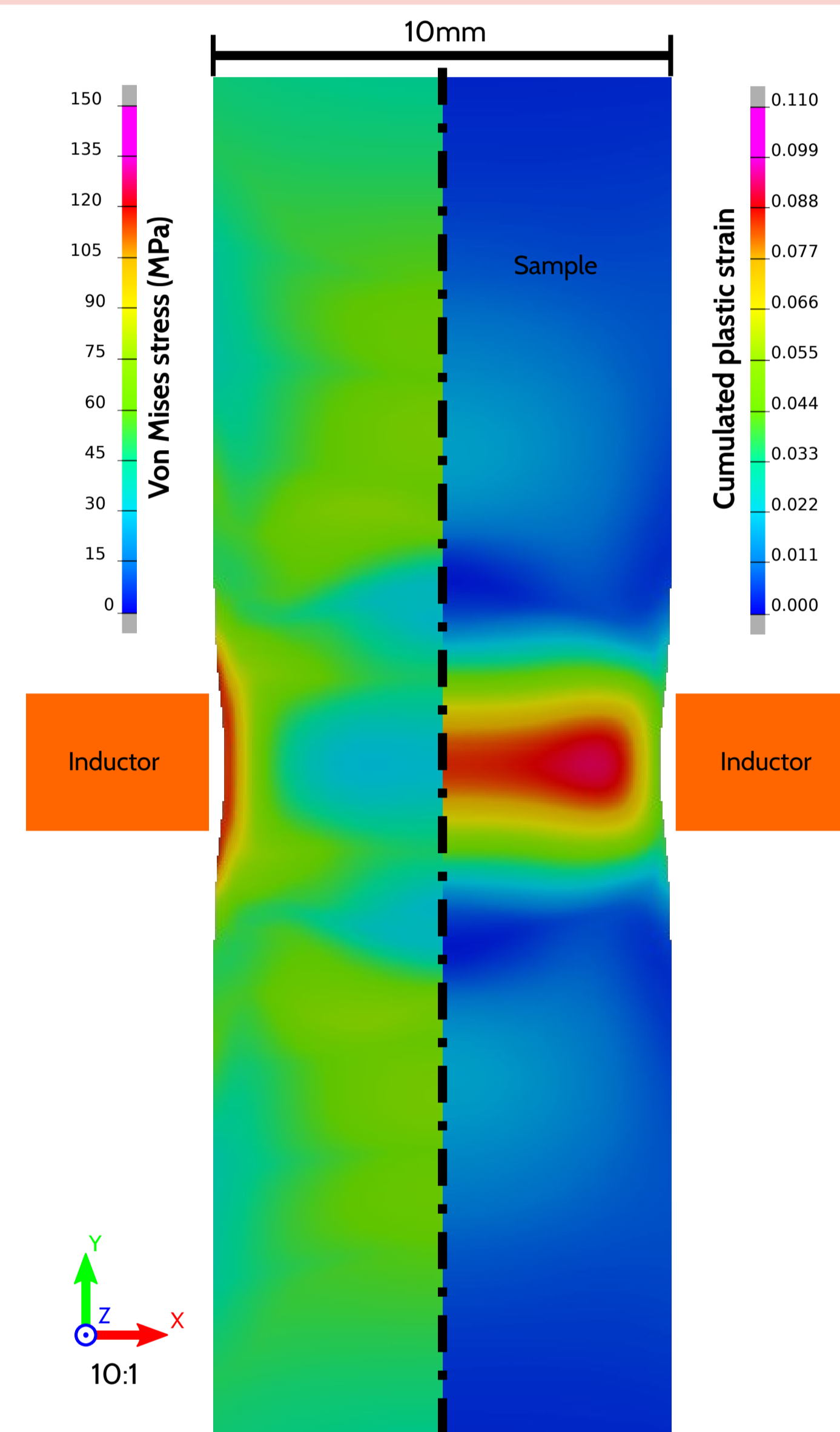


Figure 5: Simulation result (axisymmetric).

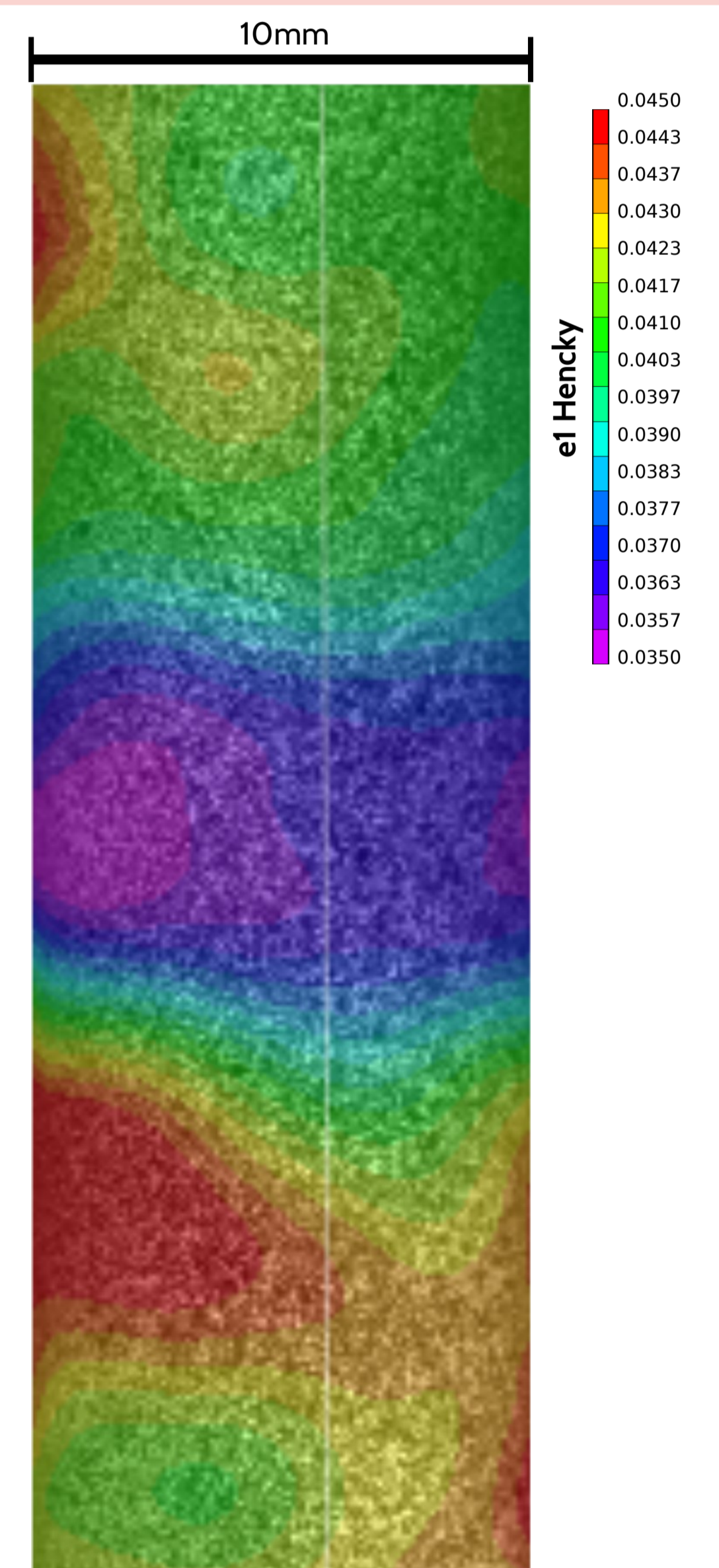


Figure 6: Strain on the sample surface after the tensile test.

We used finite element modelling (fig. 5) to:

- Ensure the validity of our geometry;
- Determine the voltage needed to induce enough force (greater than the yield point) in the test sample;
- Predict the affected area, and the depth of treatment.

## RESULTS

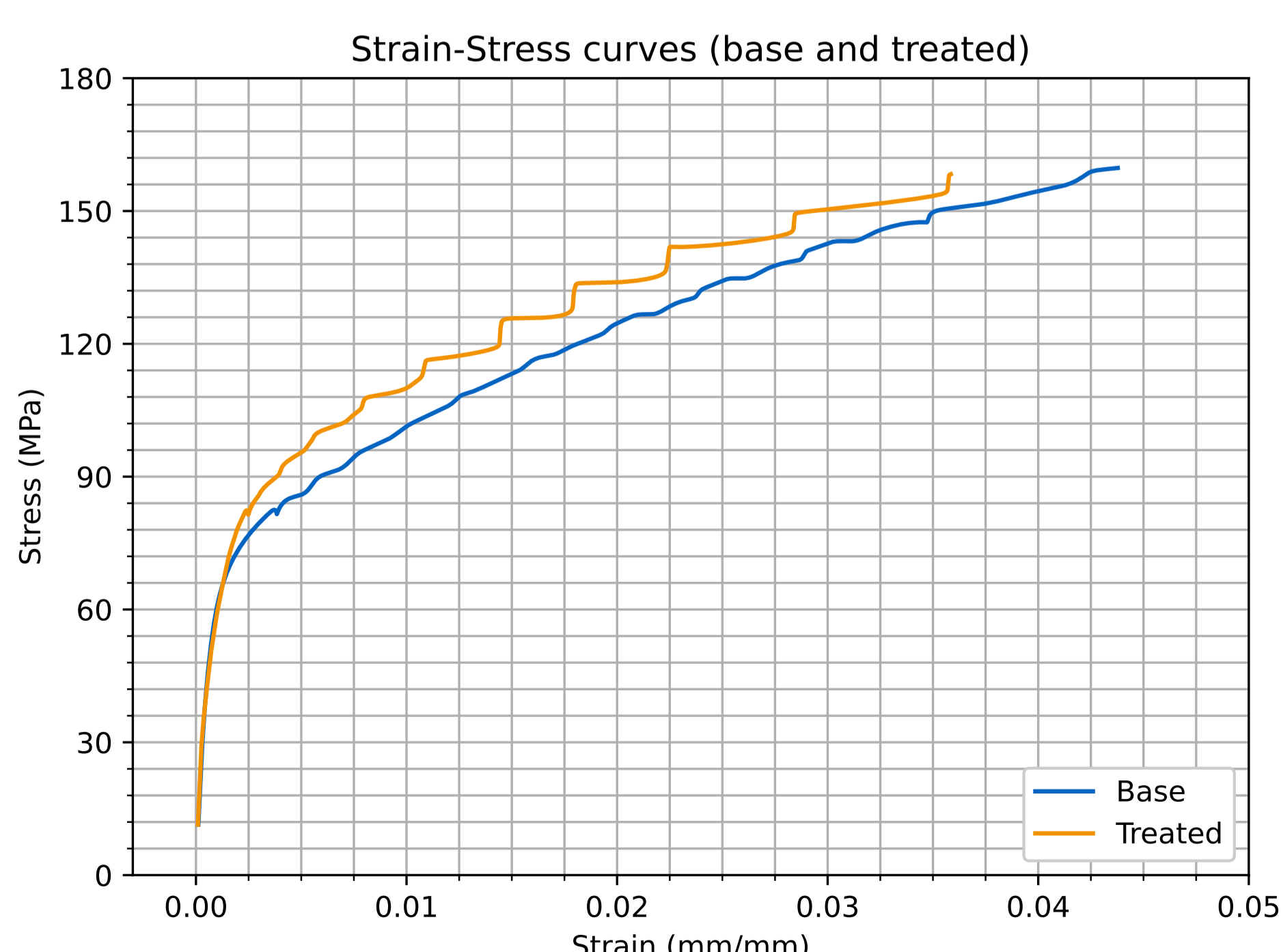


Figure 7 shows the local strain on the base and treated area, during a tensile test of a locally treated sample. The treated area shows a higher yield point than the base material.

Figure 7: Local strain along main axis during the tensile test.

## CONCLUSION & FUTURE APPROACHES

The simulated cumulated plastic strain shows that the sample will be deformed (and thus treated) under the whole coil, and through the whole radius (5mm). This affected area goes much more deeper than classical shot peening[3].

The first results (165kA pulse, generating 45 Tesla in the sample) are promising. The tensile test after the treatment (figs. 6 and 7) shows that the impacted area is indeed well treated, as it stretches less than the mean value.

More tests and studies are still necessary to confirm and refine our test method. In the future, microstructural observation and hardness tests will be made.

## REFERENCES

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- [3] Sonde, E., Chaise, T., Nelias, D., Robin, V., 2018. Numerical simulation of electromagnetic surface treatment. Journal of Applied Physics 123.045901. <https://doi.org/10.1063/1.5007344>