Understanding a steel material when it is being formed – for creating more realistic simulations.

What does it take to form a material such as steel? How does it behave during forming? If you have the knowledge of it. How can you describe this behaviour virtually to be as close as the real world application? In this thesis we answer these questions when we investigate the material behaviour of one specific steel that is often used in food and beverage processing industries.

The forming of the material was made with a tensile test – a test where a stretching load is applied to a sample until it breaks (Fig. 1). During this forming, the testing machine collects data that are used to plot two main curves, namely force-displacement and stress-strain curves. This is a common way to determine the maximum load a material can withstand and to understand how flexible it is.

Figure 1: Steel sample before and after test.

Generally, by creating a virtual test, one can change different test conditions, e.g. the geometry and how fast the material is stretched, without performing actual experiments. This is where Finite Element Method (FEM) comes in handy. For this study, different softwares were used to create the virtual environments that mimicked the physical experiments.

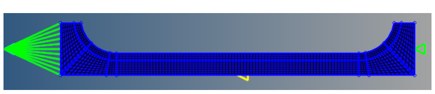

Figure 2: Example of how the steel geometry was modelled.

The geometry was divided into so-called elements as illustrated in Fig. 2. Each element is described with a set of differential equations and need to be solved according to the specified conditions. Therefore, the more realistic it is described, the more computational time is needed. Finally, the solutions for the elements are put together to simulate the test, and results are exported to allow comparison with the physical test. FEM is often used by engineering companies to reduce cost in experiments and to be able to optimize different parts of a system during a product development phase.

The material was a stainless steel denoted 316L which proved to be quite flexible. Consequently, the obtained data contained many points depending on how fast the forming was made. Therefore, the material behaviour is often approximated in different ways to reduce computational time.

Three types of approximations, called material models, were investigated: bilinear, multilinear and Johnson-Cook. These were the ones that were common in research for this material. Comparison of the virtual test results, using these models, with the physical data was then made. It was found that the material behaviour was dependent on how fast the forming was made. Moreover, similar characteristics to the physical tests were best captured with the Johnson-Cook approximation.

This knowledge was then applied to a manufacturing process using the same steel. Tubes made of the material were virtually formed with the proposed material models. The results were compared with a material model that is today used by the company and the findings also showed that the material behaviour was best described with the Johnson-Cook material model. The manufacturing process is therefore better understood and the awareness can be used for future improvements.

Iteka, R. and Adibi, P. (2019). *Material characterization of 316L.* Master's thesis at the Department of Construction Sciences, Faculty of Engineering in Lund.