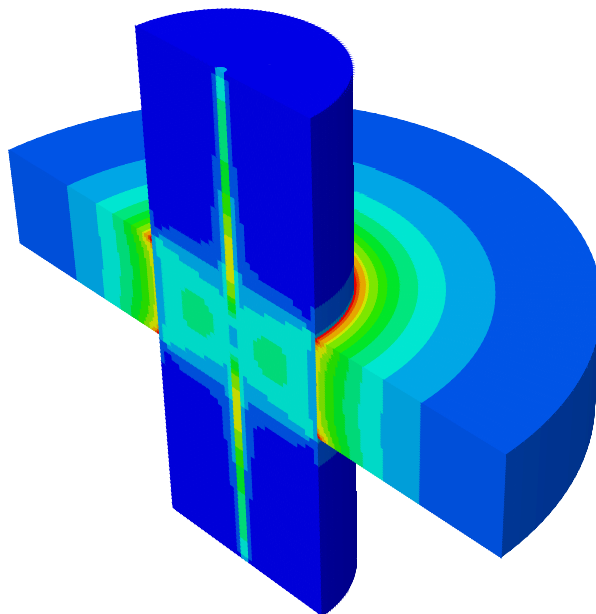


# Assignment 7

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Finite Element Analysis I

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# Abstract

In this assignment we investigate a cooling disc which is mounted on a shaft. The occurring stresses after cooling are then assessed.

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# 1 Introduction

This assignment should show an introduction in thermo-mechanical simulations. With a numerical model of a disk and shaft, the disk is heated up to increase its diameter, then cooled down to form an interference fit. This is a common procedure in mechanics to fit parts together (e.g. bearings on shafts). It is therefore interesting to know, by how much the disc has to be heated in order to get an inside diameter which fits over the shaft. In a practical application, this could be used to specify manufacturing tolerances. Assuming the disc is uniform and isotropic (the same in different directions), the hole will expand in the same ratio as the metal. You can see this because of the thermal expansion equation.

$$\delta l = l \cdot \alpha \cdot \delta t \quad (1)$$

$l$  = original length

$\delta l$  = thermal expansion

$\alpha$  = coefficient for heat expansion

$\delta t$  = temperature difference

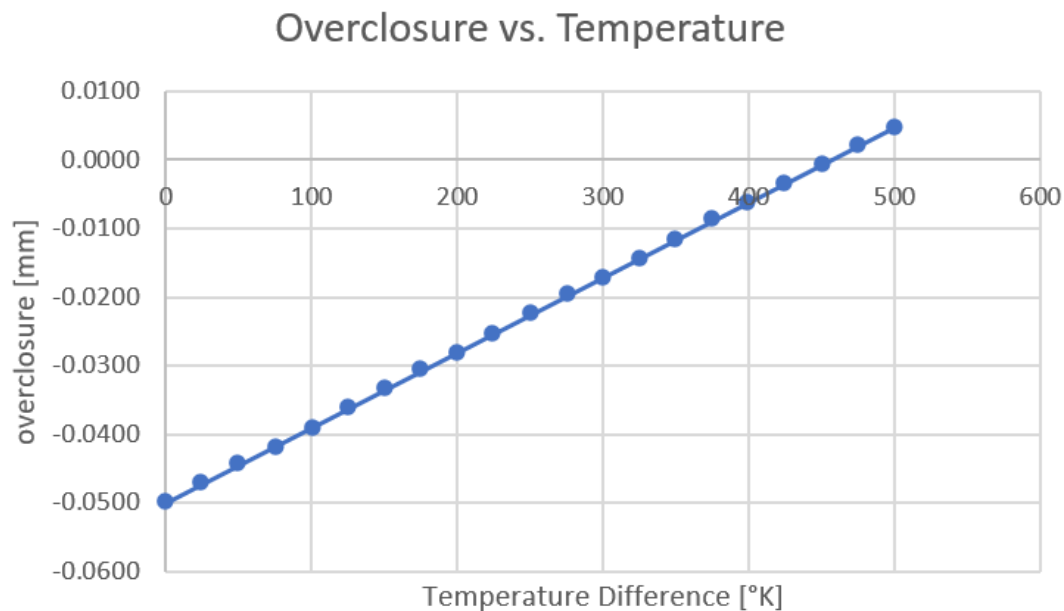


Figure 1: overclosure

## 2 Methods

### 2.1 Diameter as Function of Temperature

The inside diameter of the disc changes with temperature. The rate of change depends on the thermal heat expansion coefficient.

### 2.2 Modelling

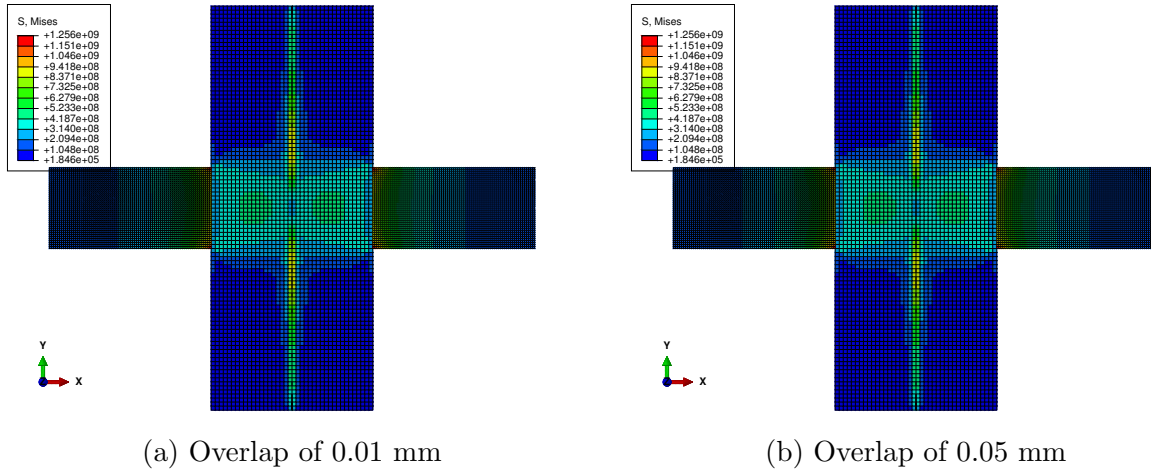
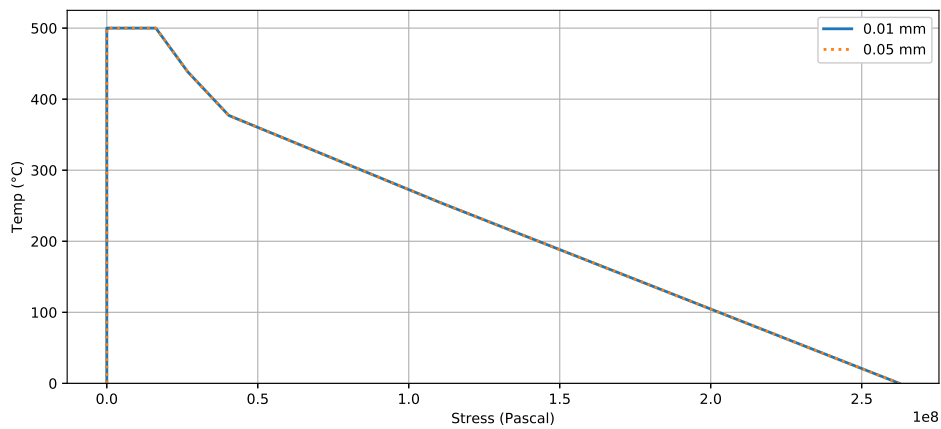


Figure 2: Comparison of overlap

It is important to sequence the model into different steps. Contacts are only activated after both instances are clear of each other (after heating up the disc).



### 3 Results and Discussion

The results vary greatly with different mesh sizes. Especially when using quilt plots, results may differ quite heavily from one mesh to another, as there is no averaging between elements. Quilt plots are good for evaluation on an element-by-element basis. We reach a maximum mises stress of around 1.2GPa, which is way below the plastic deformation threshold for the shaft material, which lies at 200GPa. However, it is also possible that this maximum value of 1.2GPa comes from the thermal deformation of the part itself during heating up. When thinking about the real world application, it seems reasonable that the maximum stresses stay in the elastic region of the materials, because the shaft could not be reused after the disc (or bearing) would be removed. The simulation with a smaller overlap of the parts shows no smaller stress value at the surface. This is qualitatively a questionable result. We would assume, that by having a smaller overclosure, lower stress values would result. From a practical perspective, by dimensioning the overclosure to a certain value (during manufacturing of the parts), engineers can influence the behaviour of the assembly, mainly its ability to withstand axial loads. We assume that there might be errors in the selection of the respective nodes for plotting, or possibly in the material characteristics. However, due to lack of time we were not able to fully investigate further. Corrected results may follow in an appendix to this report.

## References

- [1] [https://www.engineeringtoolbox.com/thin-circular-ring-radius-temperature-change-d\\_1612.html](https://www.engineeringtoolbox.com/thin-circular-ring-radius-temperature-change-d_1612.html)