# Mechanical tests and constitutive modeling of metastable austenitic stainless steels

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## Introduction

Metastable steels (steels that comprise a meta-stable phase) undergo phase evolution during a mechanical forming process. The metastable phase in austenitic stainless steels is austenite, $\gamma$ , which transforms into martensite, $\alpha'$, under the action of applied strain and stress. The transformation itself causes additional straining of the material and the presence of $\alpha'$ hardens the material significantly.

## Objective

The aim of this project is to develop a constitutive model that can simulate the mechanical behavior of TRIP steels under complex forming operations.

## Methods

### Thermodynamics

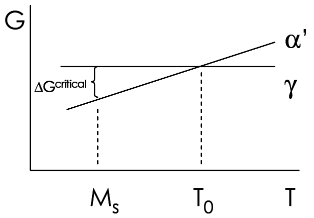
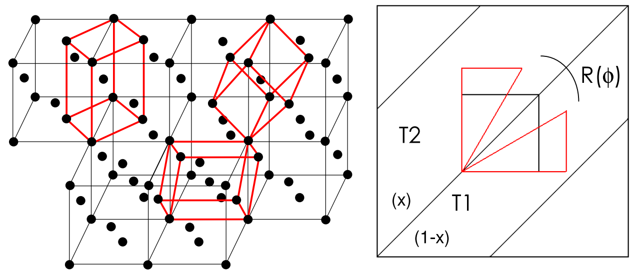



*Figure 1 : $M_s$ and the Gibbs free energy curves of $\gamma$ and $\alpha'$ dictate the energy barrier for transformation.*

### Crystallography




$$F^{tr} = (1-x)T_1 + xR(\phi)T_2$$
$$\dot{F}^{tr} = I + \dot{\xi}(sn) \;\Rightarrow\; W = \sigma : (sn)$$

*Figure 2 : Lattice correspondence between $\gamma$* 'fcc' *and $\alpha'$* 'bcc' *and the transformation mechanism via* Bain *strain and* twinning.

Using the work associated with the transformation of one variant the *mechanical driving force* (MDF) can be estimated over the polycrystal.

## Mechanical tests

### *Prestrain*

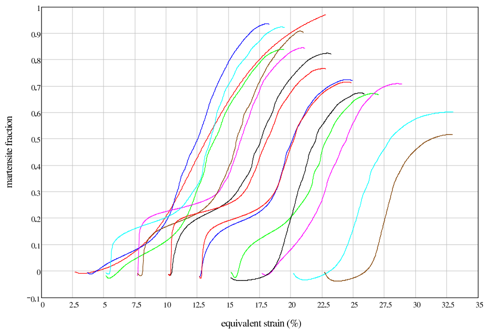



*Figure 3 : Effect of transformation-free plastic prestrain on further transformation kinetics.*

Using these experimental results the effects of plastic strain on the transformation kinetics are quantitatively investigated.

### *Biaxial*

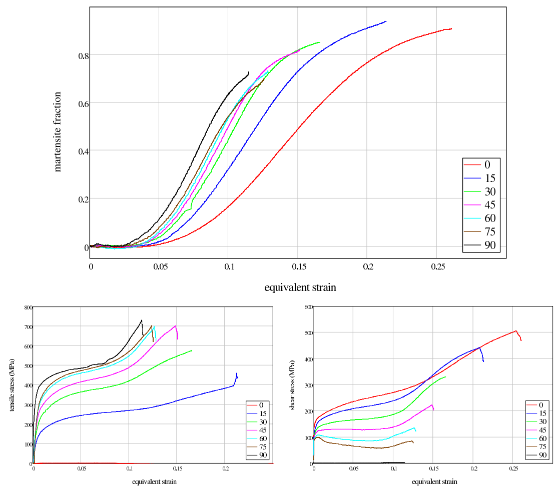



*Figure 4 : Effect of hydrostatic stress on transformation kinetics.*

The results show that the transformation curves have the same shape with respect to strain and scale in this space linearly with hydrostatic stress.

## Discussion

Mechanical tests quantify the effects of parameters that drive the transformation, $\epsilon^p$ and $\sigma$. Using these results and the thermodynamical findings, phenomenological models will be developed to predict transformation.

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