NUMERICAL STUDY OF THE BENDING OF STEEL SHEETS TRIP 304L

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Abstract

Folding is a common industry practice. In this work we have studied the influence of some parameters such as (the radius of curvature of the matrix, the coefficient of friction between the punch and the specimen, the play between matrix and punch, the thickness of the specimen and the mesh of the specimen) on the deformations of the different zones of the specimen, by a numerical simulation of U-bending using the ABAQUS calculation code.

The studied parameters will prove to be of relevant use for the design of the parts from the metal sheets, through the bending forming process. Numerical simulation is a good decision support tool for parts manufacturing companies.

For the continuation of this work, a phenomenological model developed by IWAMOTO has been selected and modified to include the evolution of the microstructure (from austenite to martensite) after deformation.

Keywords: Folding, TRIP steel, simulation, abaqus

1. INTRODUCTION

The manufacture of the parts from the sheets is generally carried out on presses, using a punch and a die. As product quality criteria are becoming increasingly stringent in terms of geometrical precision and mechanical performance, it is very often necessary to optimize the forming process. The success of a product manufactured by stamping, embossing or more particularly by bending depends essentially on three interrelated factors [1]:

- The physical characteristics of the sheet metal,
- Tool geometry,
- Lubrication.

Our work, which is based on the numerical simulation of the U-bending forming process in the ABAQUS finite element calculation code, aims to study the influence of some geometrical parameters on the bending load, such as the mesh, the thickness of the specimen, the coefficient of friction between the punch and the specimen, the clearance between the punch and the die and the radius of the die.

A phenomenological model developed by IWAMOTO and TSUTA [2] was then chosen and modified to include the evolution of the microstructure (austinite and martenesite) in steel [3].

2. THE USED MATERIAL

The material used is an unstable austenitic steel from the 304L family in the form of thin sheets. The (L) stands for low carbon steel. The chemical composition and designation of the steel is given in the following tables [4]:

Table 1 Chemical composition of stainless steel 304L

Elements	C	Si	Mn	P	S	Cr	Ni	N
(%)	0.03	1.00	2.00	0.045	0.015	18.18	8.04	0.10

Table 2 Material designation according to different standards

Norms	EN	DIN 17440	AISI	AFNOR
Designations	1.4301	X5CrNi18-9	304	Z6CN18-9

3. NUMERICAL SIMULATION OF U-BENDING

In this study, we consider the operation of U-shaped bending of a specimen, made of TRIP 304L steel, using a 3D numerical simulation, on the ABAQUS finite element calculation code, with a Static-General resolution scheme, taking into account elasto-plasticity.

The principle of this operation consists of deforming a sheet metal held fixed between the die and the blank holder, under the action of a punch, in order to obtain a bending angle which can in no case exceed a value of 90°.

The dimensions of the specimen used are shown in the **Figure 1**.

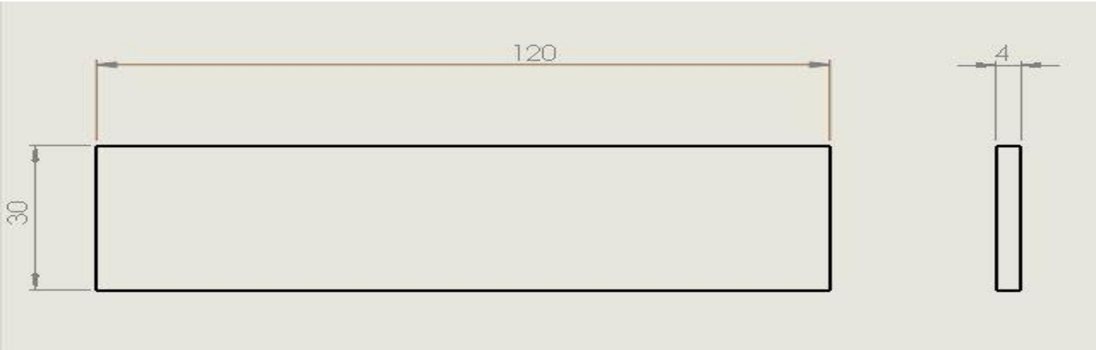

Figure 1 Dimensions of the specimen used

The digital mock-up is shown in **Figure 2** in the initial position. In this study, the tools are modelled by rigid bodies, the specimen is meshed by eight-node quadratic elements, given by ABAQUS. Punches and dies are generally radiated to facilitate shaping and avoid the initiation of rupture [5].

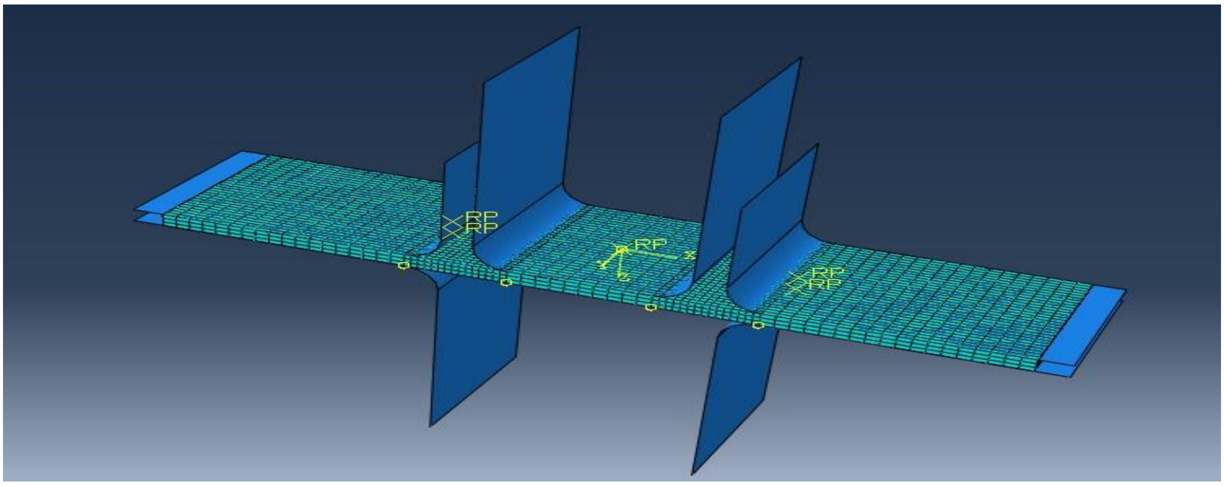

Figure 2 Digital mock-up of the bending of the specimen used

4. STUDY OF THE INFLUENCE OF SOME PARAMETERS

4.1. Study of the influence of the mesh

We study the influence of the specimen mesh by varying the value of the size of the finite elements with which we discretized it, in our case we will choose three mesh values: 1 mm, 1.5 mm and 2 mm (**Figure 3**).

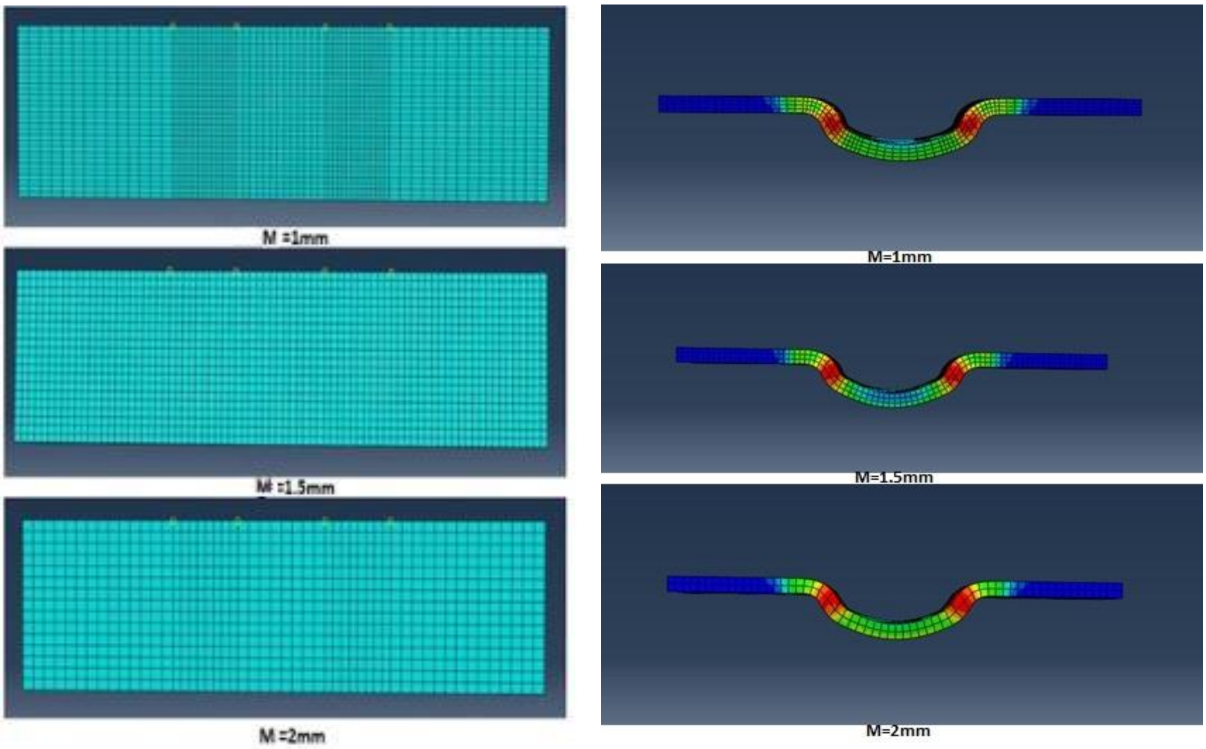

Figure 3 Different mesh sizes and overview of the deformation with constant displacement *u* = 10 mm

The **Figure 4** show us that refining the mesh increases the bending load, which is explained by the fact that if the elements are very large the load are not calculated correctly. The mesh size must be fine enough so as not to influence the results.

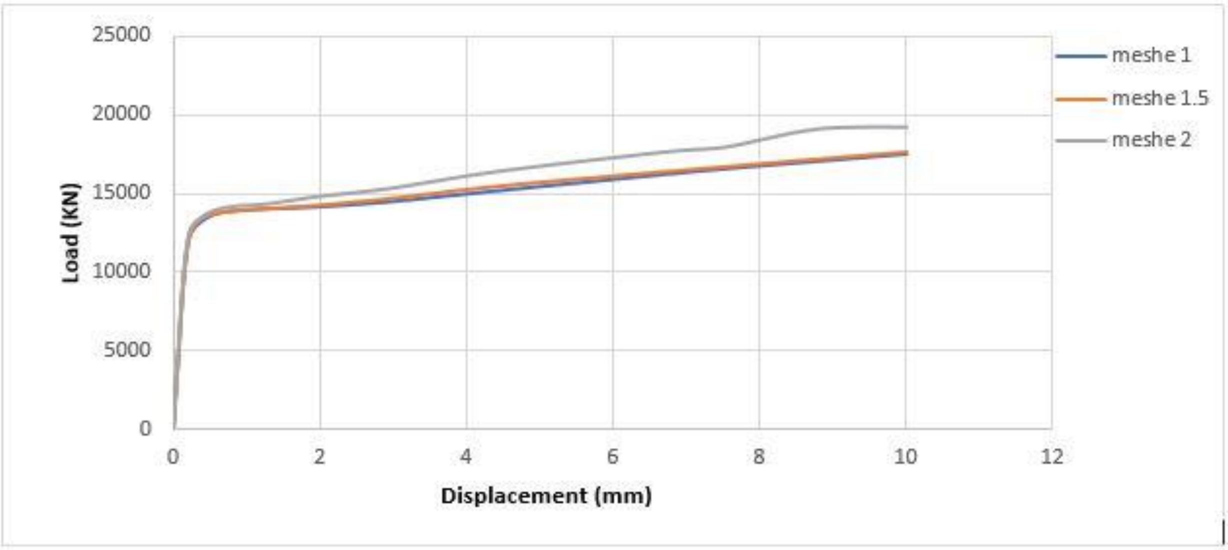

Figure 4 Load-displacement curves of different meshes

4.2. Study of the influence of thickness

To demonstrate that the thickness of the specimen influences the bending load, the value of the thickness of the specimen is varied as shown in **Figure 5**.

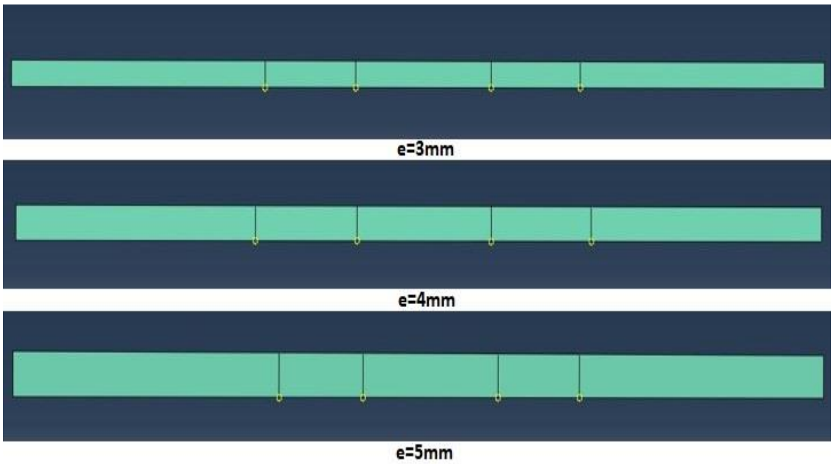

Figure 5 Thickness variation

In **Figure 6**, we see in his results that the bending load increases with increasing specimen thickness, which is logical.

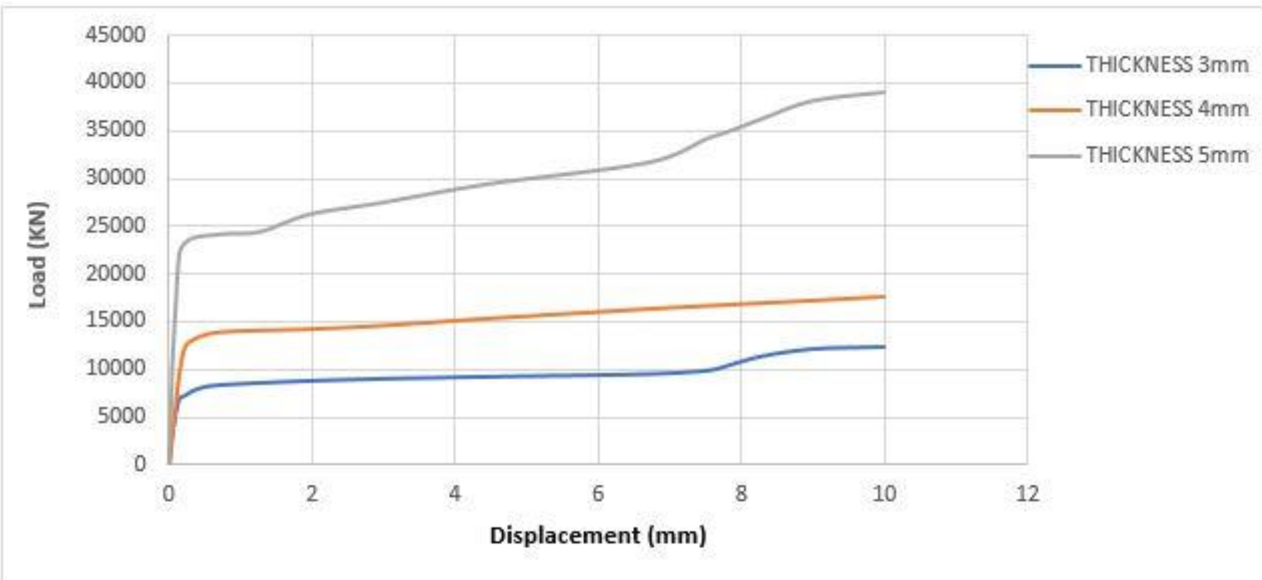

Figure 6 load-displacement curves of different thicknesses

4.3. Study of the influence of friction

We vary the friction coefficient to see its influence on the bending load, we take the following values: f = 0.09, f = 0.2 and f = 0.3 (**Figure 7**).

The results given by the curves represented by (**Figure 7**), show that the variation in the coefficient of friction installed between the specimen and the punch affects the value of the bending load; it increases by increasing the coefficient of friction, which is explained by the considerable load exerted by the punch in order to bend the specimen.

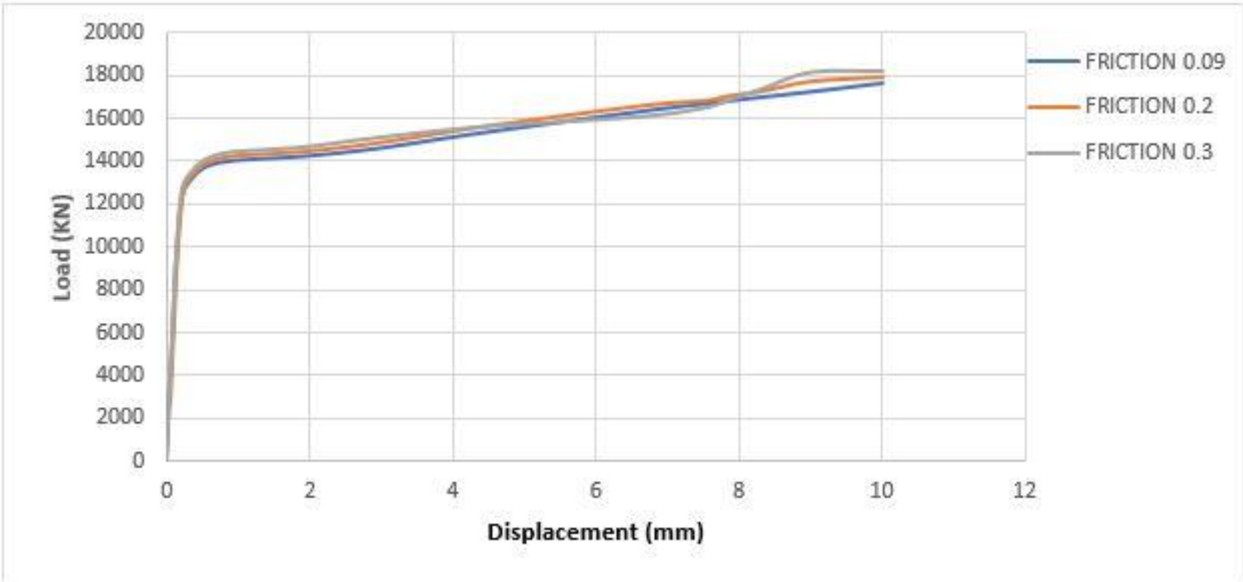

Figure 7 load-displacement curves of different coefficients of friction

4.4. Study of the influence of gambling

In what follows we have proceeded to vary the play between the punch and the die (Clearance1 = 0.25 mm, Clearance 2 = 0.5 mm and Clearance 3 = 0.75 mm), in order to see its influence on the bending load.

We notice in **Figure 8** that each time the play is decreased; the value of the bending load increases, which is explained by the important effects of the friction between the punch and the sheet metal. This resistance to the advance of the punch results in an increase in the load required for bending.

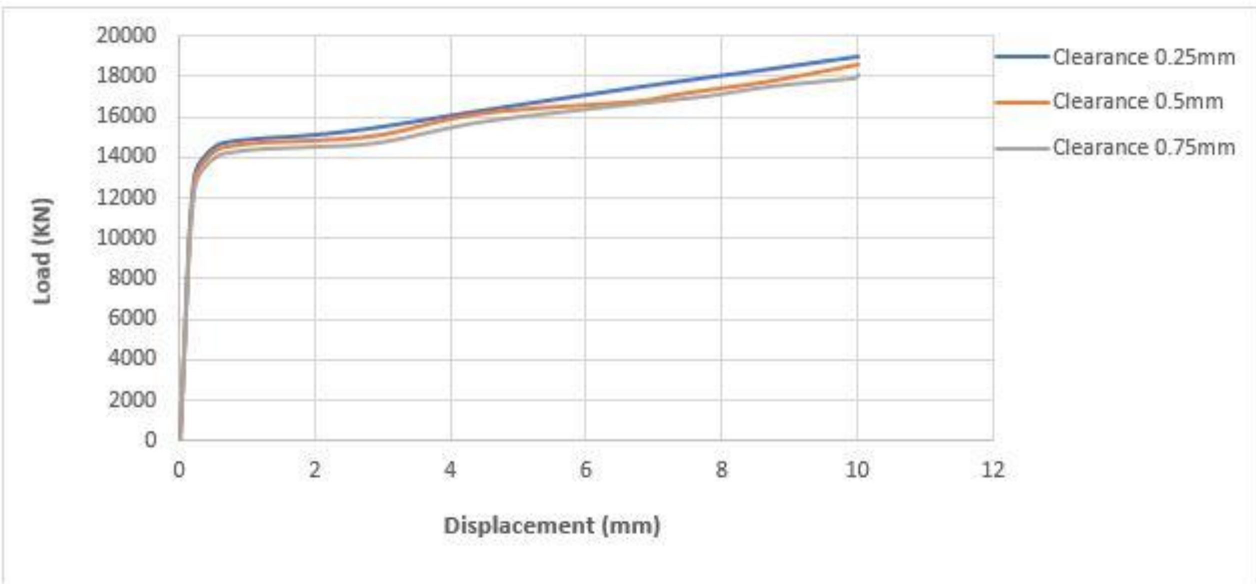

Figure 8 Load-displacement curves of different sets

4.5. Study of the influence of the radius

To demonstrate the influence of the radius of the matrix, we vary it on ABAQUS, this allows us to obtain the results given in **Figure 9**.

The results of our simulation show that the load required for bending is higher when the radius of the die is smaller. The smaller radius of the die results in greater deformation, the material becomes stronger and requires greater efforts to bend the specimen.

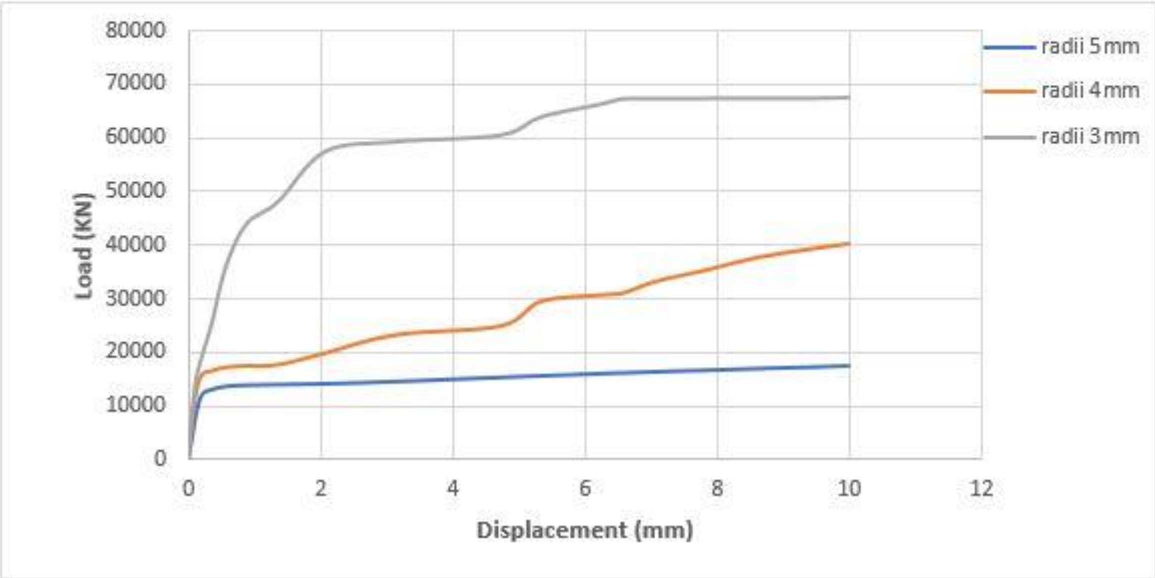

Figure 9 Load-displacement curves of different radii

5. CONCLUSION

We presented the elasto-plastic model coupled with static deformation. We performed a calibration of the parameters as well as their influences on the load-displacement curve, and we saw that the studied parameters all have an influence, such as silk, on the bending load and the deformation of the specimen and thus on the transformation of austenite into martensite.

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