

## The Simulation of the Tube Forming Process in Diescher's Mill

Lu Lu<sup>a</sup>, Chunxiao Liu<sup>b</sup>, Hongxia Cui<sup>c</sup>, Jiazhi Chun<sup>d</sup>

College of Information Science and Technology, Bohai University, Jinzhou, Liaoning, China

<sup>a</sup>lulu\_me@163.com, <sup>b</sup>252423132@qq.com, <sup>c</sup>94249181@qq.com, <sup>d</sup>76763867@qq.com

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**Abstract:** The finite element method (FEM) was used for simulation of piercing process of the tube in Diescher's mill. A thermal dynamic numerical method is carried out to model the behavior of steel 33Mn2V used in new Non-Quenched/Tempered oil well tubes in the piercing process. The numerical model is described taking into consideration thermal phenomena in metal during forming. On the basis of the basic parameters, the phenomenon in the piercing process is analyzed.

### 1. Introduction

Nowadays seamless pipes are produced by the following three types of rolling. First, thick pipes are produced from bars by pierce rolling. Next, thin pipes are produced from the thick pipes by elongation rolling. Finally, seamless pipes, which are final products, are produced from the thin pipes by reduction rolling. The barrel-type rotary piercing is used widely in the world. Among the barrel-type rotary piercing, the best productivity and high quality of thick-walled tubes are obtained when two rolls rolling mills are used with two guiding discs of Diescher type [1-2].

The Diescher tube piercing is very complex process of the material flow. The process relies on the cyclic mechanical loading of the material caused by the conical shape of the rolls and their rotation. To prevent such empiric procedure and reduce cost, numerical simulation of forming processes is applied increasingly and is becoming a very important tool for the design and development of new products. Finite Element Method (FEM) is most widely used in numerical simulation methods. Not only can it be used to proof the feasibility of the production process, but also to predict the microstructure and beyond that the properties of the component [3-4].

The steel 33Mn2V is a new-type micro-alloyed N80 grade, Non-Quenched/Tempered and hot rolling steel for seamless oil well tube. It has been successfully utilized by Wuxi Seamless Steel Tube Company (WSSTC), Ltd. to produce seamless steel tubes which meet the API standard and have been sold all over the world.

Fig. 1 shows the material is pulled-in along a helical trajectory and a depressive mode causes a hole to form and develop in the billet.

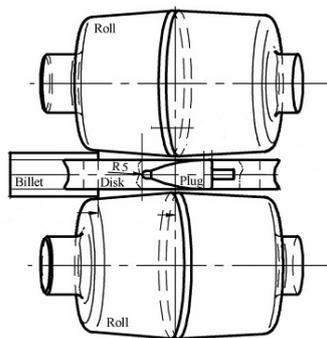


Fig. 1. Schematics of the process and the tools [5]

## 2. Numerical Model

The software Super Form 2005[6-7] is used as the basis for modelling the process. Five tools are included in the model: two rolls, two discs and a plug, as depicted in Fig.3. The chemical composition of 33Mn2V steel sample used in our physical experiment is shown in Table 1. Since the rheological stress data of steel 33Mn2V are not included in the database of MSC.SuperForm 2009 software, therefore, it's necessary for us to build a new one experimentally. The samples were taken from the same parts as those on continuous casting and rolling 33Mn2V tube provided by Wuxi Seamless Steel Tube Company. Then these samples are machined to be the specimens with the size of 8×15mm. According to the processing parameters in real production, we carried out the hot forge experiments on thermal/mechanical analog device, and then the obtained rheological stress curve (as shown in Fig. 2) was input into the computer in terms of the format required by MSC.SuperForm 2009 software. The thermo-physical parameters such as heat conductivity, specific heat, and coefficient of heat expansion etc. can be input directly from the interface window of the software. And the physical parameters at high temperatures can be acquired by extrapolating the data in Table 2. The constitutive law<sup>[8-12]</sup> for the steel grade of interest writes:

$$\sigma = m_0 \exp(m_1 T) \varepsilon^{m_2} \dot{\varepsilon}^{(m_3 T + m_4)} \quad (1)$$

The material parameters are obtained from experimental tests:

$$\sigma = 1.1244 \exp(6243.9238 / T) \cdot \varepsilon^{0.1571} \cdot \dot{\varepsilon}^{(0.0003T - 0.1933)} \quad (2)$$

Table 1. Compositions of experimental material in wt%

C	Mn	Si	S	P	V	N	Ti	Other
0.32	1.70	0.29	0.006	0.013	proper	proper	proper	proper

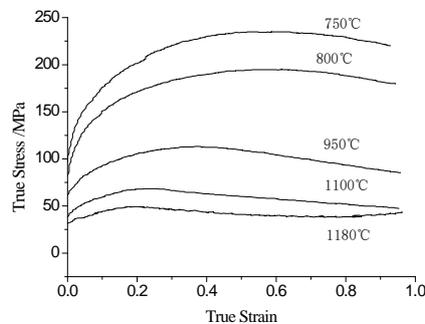


Fig. 2 Rheological stress at strain rate (s-1) = 0.02 under different temperatures

Table 2. Thermo-physical property parameters of 33Mn2V steel

Temperature / °C	Young's modulus / G Pa	Poisson's ratio	Conductivity / (W.m <sup>-1</sup> .K <sup>-1</sup> )	Specific heat capacity / (J.kg <sup>-1</sup> .K <sup>-1</sup> )	Thermal expanding coefficient / (10 <sup>-6</sup> /K <sup>-1</sup> )
20	206	0.300	-	-	-
100	203	0.300	35.0	469	12.2
200	179	0.305	35.8	502	13.9
300	190	0.310	33.2	527	13.5
400	183	0.310	31.3	543	13.8
500	174	0.310	29.3	548	14.0

The contact with the billet and the rolls is assumed to be close to sticking friction. Sliding modes are applied to model the contacts between the billet and the guides.

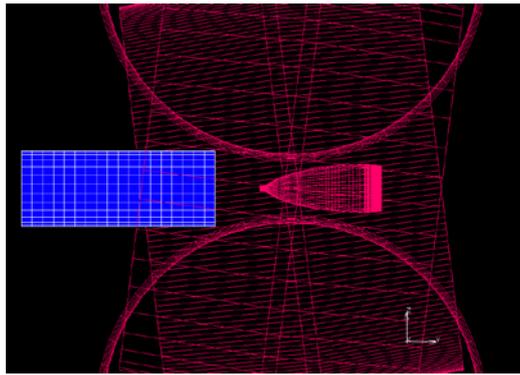


Fig. 3. Position of the tools in the numerical model

### 3. 3-D FEM Model of Piercing Process in Diescher's Mill

Due to the application of FEM it is possible to analyze precisely the changes of workpiece shape present during piercing process. They are shown in Fig.3. At the beginning of the process the workpiece is grabbed by rolls which impose a rotary movement and draw it into the zone between the rolls. After about 1.5 s, the plug touches the head surface and the cavity forming begins. After two second (for  $t \approx 3.5$  s) the remeshing begins, the workpiece is drawn into the 1/3 part of plug by the axial forces. After a forming time  $t \approx 7.5$  s, the piercing process reaches stable conditions with relative stability of forming forces.

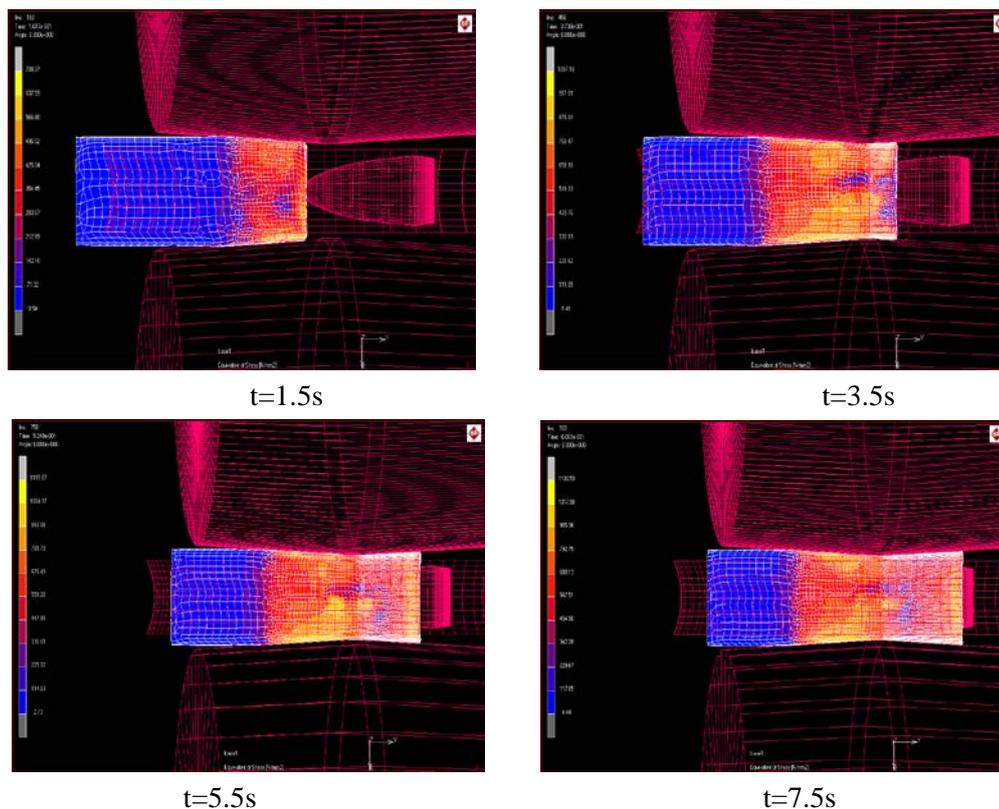


Fig.3 Calculated by FEM progression of shape (together with the strain distribution) of the workpiece during piercing, at the time t given in the picture.

#### 4. Conclusions

This paper presented the rheological stress curve of the new-type steel 33Mn2V via thermal-mechanical physical experiments and the 3-D thermo-mechanical model of the tubes piercing process in two rolls skew rolling mill Using this model and the commercial software MSC.SuperForm2009, numerical simulations of the whole piercing process were made. It was possible to calculate effectively such a complex metal forming process by applying the FEM method.

The studied result in this paper provides important realistic meaning and application value for defining reasonable parameters of force and energy, perfecting theory of skew rolling for developing Diescher's mill.

#### Acknowledgements

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