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INFLUENCE OF THE INITIAL BILLET SECTION GEOMETRY ON THE MECHANICAL PROPERTIES OF THE PIPES

БАСТАПҚЫ ДАЙЫНДАМАНЫҢ ҚИМА ГЕОМЕТРИЯСЫНЫҢ ҚҰБЫРЛАРДЫҢ МЕХАНИКАЛЫҚ ҚАСИЕТТЕРІНЕ ӘСЕРІ

ВЛИЯНИЕ ГЕОМЕТРИИ СЕЧЕНИЯ ИСХОДНОЙ ЗАГОТОВКИ НА МЕХАНИЧЕСКИЕ СВОЙСТВА ТРУБ

Abstract. *In this work, the process of rolling a continuously cast hollow billet is researched in comparison with the traditional technology for producing hot-rolled pipes: piercing and rolling of a sleeve. The experimental part describes the computer simulation algorithm in the Deform 3D software package and performs a comparative analysis of the deformation results for various types of the initial billet and pressure treatment processes. As a result of modeling, the advantages of the proposed technology for producing seamless pipes were revealed.*
Keywords: *Modeling, piercing, rolling, sleeve, mechanical properties, structure.*

Аңдатпа. *Бұл жұмыста ыстықтай илемделген құбырларды өндірудің дәстүрлі технологиясымен салыстырғанда үздіксіз қуыс дайындаманы илемдеу процесі зерттелді: гильзаны тесу және илемдеу. Эксперименттік бөлімде Deform 3D бағдарламалық кешеніндегі компьютерлік модельдеу алгоритмі сипатталған және бастапқы дайындаманың әртүрлі түрлеріндегі деформация нәтижелеріне және өнімді қысыммен өңдеу процестеріне салыстырмалы талдау жасалды. Модельдеу нәтижесінде жіксіз құбырларды алудың ұсынылған технологиясының артықшылықтары анықталды.*
Түйін сөздер: *Модельдеу, тесу, илемдеу, гильза, механикалық қасиеттері, құрылымы.*

Аннотация. *В данной работе исследован процесс раскатки непрерывнолитой полой заготовки по сравнению с традиционной технологией получения горячекатаных труб: прошивка и раскатка гильзы. В экспериментальной части описан алгоритм компьютерного моделирования в программном комплексе Deform 3D и произведен сравнительный анализ результатов деформации при различных видах исходной заготовки и процессов обработки изделий давлением. В результате моделирования выявлены преимущества предлагаемой технологии получения бесшовных труб.*
Ключевые слова: *Моделирование, прошивка, раскатка, гильза, механические свойства,*

структура.

Introduction. At the present level of development of steel production, the continuous casting process, due to its technical and economic advantages, has established itself as the most rational method for obtaining steel billets for the production of seamless pipes.

The constant improvement of the performance properties of steel products is ensured by the use of modern solutions and developments at each stage of production. A large number of studies have been devoted to metal casting [1-3]. An important stage in the formation of the crystal structure of the billet is continuous casting. At the same time, most manufacturers of continuously cast pipe billets use the production technology according to the piercing-rolling scheme.

Most seamless pipes are made from low-alloy round section billets.. Hot-rolled pipes are manufactured in a helical rolling mill by piercing, which are subsequently rolled out in continuous hot rolling mills and shaped to final dimensions in calibration and reduction mills.

Piercing not only requires expensive equipment, tools and energy, but also affects the quality of the pipes. When the billet passes through barrel-shaped or mushroom-shaped rolls, tensile stress appears in the center of the billet and destroys its axial part. On the one hand, this facilitates the introduction of the mandrel and the formation of the inner cavity of the billet, on the other hand, this can lead to the formation of defects on the inner surface of the pipe. Also, due to the uneven axial zone of the cast billet, the mandrel can be displaced relative to the longitudinal axis of the billet, which leads to a change in the wall thickness of the pipe. In addition, for some types of steel and alloys with a significant content of chromium and nickel, piercing is difficult due to high resistance to deformation and a narrow temperature range of hot plasticity [4-6].

In this regard, the solution to this problem is the exclusion from the technological chain of the piercing process, which can be achieved by using the process of rolling a hollow cast billet. Solid billets with any production methods are characterized by segregation heterogeneity. The larger the initial cross section of the billet, the greater the degree of chemical heterogeneity over its cross section. For example, a billet with a large cross-section, which is supplied for rolling, always has an increased carbon content and most of the impurities in the axial zone. It is irrational to redistribute alloying and impurity elements over the cross section of the billet by homogenization annealing, because of the length of the process at a low diffusion rate of elements in the cast metal and the high energy consumption during such heat treatment. The low ductility of a high-carbon billet with a high content of metal impurities in the axial zone creates the risk of axial fractures during subsequent rolling. Breaks and accumulations of impurities are stress concentrators and greatly reduce the fatigue strength of finished pipes. In this regard, the removal of metal from the axial zone of a continuously cast billet is appropriate. However, the use of rolling a hollow sleeve can lead to lower mechanical characteristics of the final product, which is associated with a lower total degree of deformation of the rolled product. Thus, it is necessary to research the process of rolling a hollow billet in order to determine the feasibility of using this technological scheme for producing pipes [7-9].

Due to the complexity, and sometimes the impossibility of direct study of a real object, computer modeling is used. To modeling deformation processes, namely piercing and rolling, the Deform 3D software package [10] was used in this work.

Materials and methods of research. To analyze the flow of material in three-dimensional space in the process of metal forming, a system of computer modeling of technological processes Deform 3D was used. Deform 3D provides the necessary information about the behavior of the metal and the features of the temperature distribution during deformation based on the finite element method.

During the modeling, at the initial stage, the initial data were set in the preprocessor: billet material, billet and tool temperature, strain rate, boundary conditions.

The results of the modeling were the mechanical properties and geometry (wall thickness over the section) of the rolled products.

Results and discussion. The experiment consists in modeling two ways to obtain a seamless pipe (Figure 1) and comparing their results, which are geometry and mechanical characteristics.

The first step was modeling the piercing of a solid steel billet with a diameter of 300 mm (Figure 2).

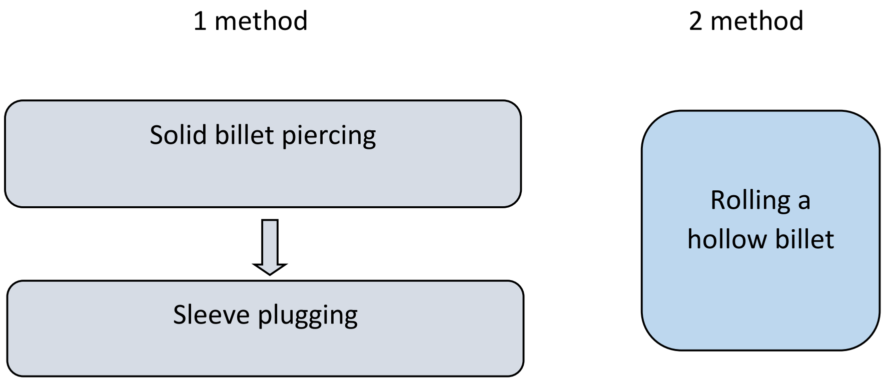


Figure 1. Methods for obtaining pipes

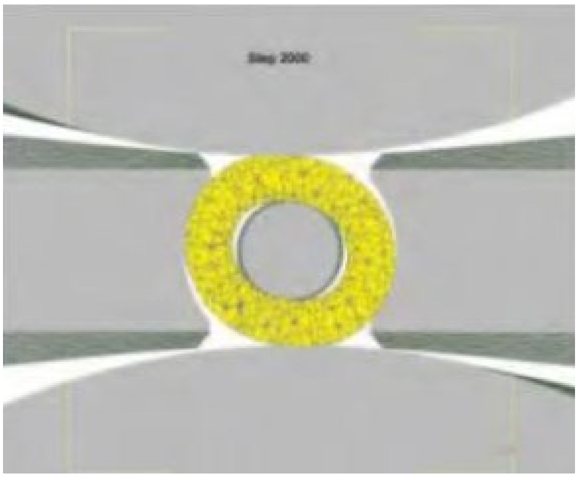


Figure 2. Deformation area of during the piercing of a solid billet

Further, using the final data of the obtained sleeve in the Deform 3D program, we set the initial data on geometry and properties to modeling the process of rolling the obtained sleeve (Table 1).

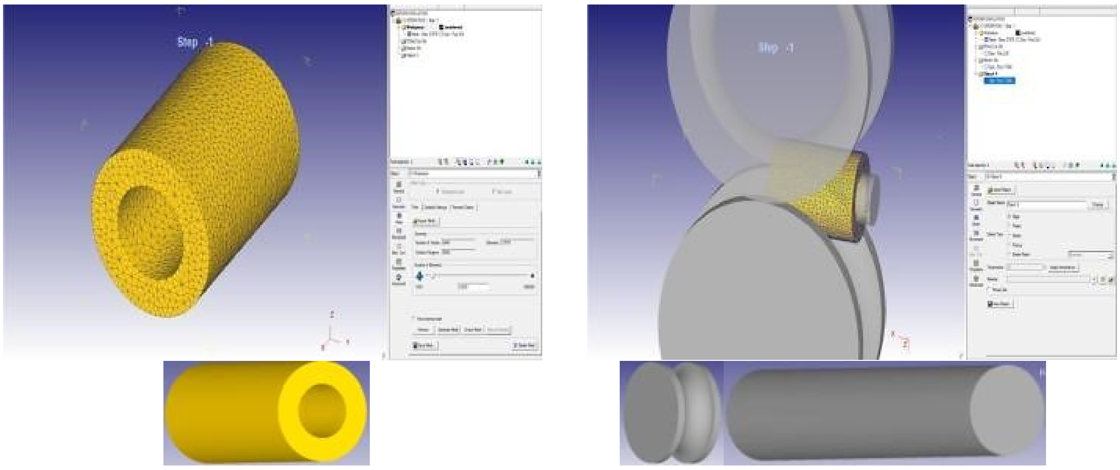
Table 1. Initial data for the rolling process

Parameter	Value
Rolling mill mandrel diameter, mm	127,0
Sleeve inner diameter, mm	127,4

Sleeve outer diameter, mm	227,0
Sleeve heating temperature before rolling, °C	1100
Steel grade	ISO-20CrNiMoS2

Upon receipt of a pipe using the technology of rolling a hollow billet, the original product undergoes smaller deformations in terms of the amount, which means that as a result, lower mechanical properties will be observed, normalized by the standards. To determine the magnitude of the difference in obtaining mechanical properties for different production methods, the process of rolling a stitched sleeve and a hollow continuously cast billet was modeling [11-15].

The geometry of the billet and technological tool for modeling in Deform 3D (Figure 3) was originally created in the «Compass» software package.



a *b*

Figure 3. Three-dimensional models for modeling rolling: a – billet; b – rolls and mandrel

To determine the mechanical properties, a tensile test was simulated (Figure 4), in which the tensile strength and yield strength were determined from the force calculated by the program, and the relative elongation was determined through the length of the sample tensile graph. The results of modeling uniaxial tension are shown in Table 2.

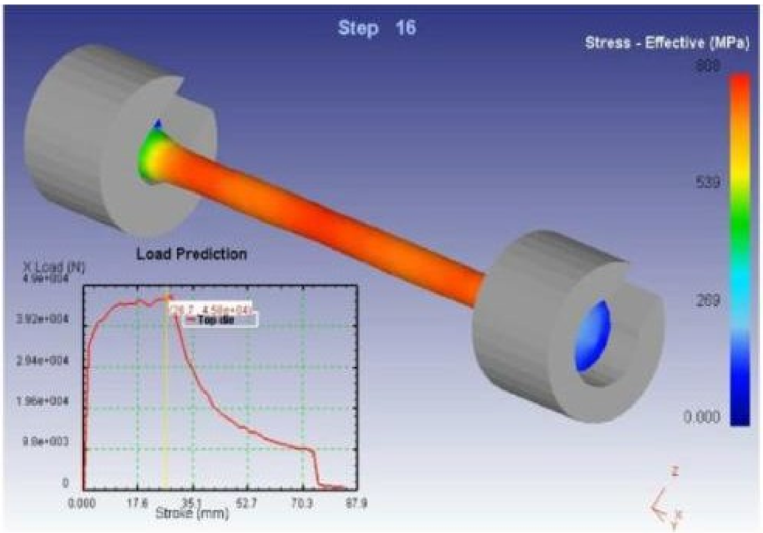


Figure 4. Modeling of the tensile test of the sample

Table 2. Mechanical properties of computer model pipe samples

Parameter	Initial billet of the rolling mill	
	pierced sleeve	hollow cast billet
Tensile strength, MPa	482	458
Yield strength, MPa	352	336
Elongation, %	15,1	14,4

As the results show, the mechanical properties of the proposed production scheme are lower than those of the traditional pipe production technology by 5 %. However, poor mechanical properties can be corrected by subsequent heat treatment.

Conclusions. The use of technology for the production of seamless hot-rolled pipes without a piercing process, using a continuously cast hollow billet, has a number of advantages:

– reducing the cost of pipe production due to the exclusion of the piercing process from the technological chain;

– improvement of the inner surface of produced pipes;

– optimization of technology for the production of seamless pipes and economic feasibility by eliminating the purchase of expensive tools for piercing mills (rolls, mandrels, guide lines).

Thus, the use of a continuously cast hollow billet as a billet for producing a hot-rolled seamless pipe will improve the quality, which is theoretically confirmed by modeling in the Deform 3D software package and is more economically feasible.

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