The Investigation of lengthwise rolling on a stub mandrel by the use of a computer simulation

IOP Conf. Series: Materials Science and Engineering **971** (2020) 022031 doi:10.1088/1757-899X/971/2/022031

The Investigation of lengthwise rolling on a stub mandrel by the use of a computer simulation

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Abstract. Lengthwise rolling of pipes on a stub mandrel is one of the most common pipe rolling methods. An urgent problem of the process of lengthwise rolling of pipes on a stub mandrel is the increased wall thickness variation in rough pipes caused by the flow of metal into the groove tapers and the formation of stripes during the rolling process. Therefore, an important direction is the study of the inhomogeneity of the metal flow in the deformation zone during the rolling process. To evaluate the wall thickness variation during the rolling process, a dimensionless parameter was introduced, which is the ratio of the average wall thickness variation in the groove tapers to the average wall thickness at the groove tops. The article presents the results of a study of the influence of mandrel calibration on the wall thickness variation and the tendency to form defects on the inner surface. With the use of computer simulation made for structural alloyed steel AISI-4140, the shape change of the pipe is investigated. Based on the studies, practical recommendations are formulated when choosing the calibration of the mandrel during lengthwise rolling on a stub mandrel, providing increased accuracy of pipes and reducing the level of defects.

1. Introduction

An important scientific and technical problem is increasing of the accuracy of hot-rolled pipe dimensions. The urgency of this problem takes place at pipe-rolling plants with automatic rolling mills, as well as tandem mills. Automatic rolling mill "tandem" consists of two successively located lengthwise rolling mills (LRM-1 and LRM-2), rolling is carried out at relatively low reduction ratio. At LRM-1 the reduction ratio is equal to $\lambda = 1.16 \div 1.5$, and at LRM-2 - $\lambda = 1.07 \div 1.15$. During rolling at LRM-1 an increase of the wall thickness at the groove tapers takes place and ridges are formed (figure 1) [1, 2], which leads to a wall thickness difference of the pipe. Then, at LRM-2 the formation of jaws occurs in the region of the groove tapers as a result of the metal counter flow (figure 2). As a result of the jaws formation, a “guide mark” defect is formed at the inner surface of the pipe (figure 3). It is known that metal forming is largely dependent on mandrel calibration. In this work we investigated the shape change of the pipe metal during lengthwise rolling on a stub mandrel, depending on the taper angle (figure 4) of the mandrel for the lengthwise rolling mill (LRM-1).

2. Setting up of a computational experiment and investigating of the pipe shaping

The study was carried out with the help of the «Deform» software using the method of computer modeling of technological processes [3-6].

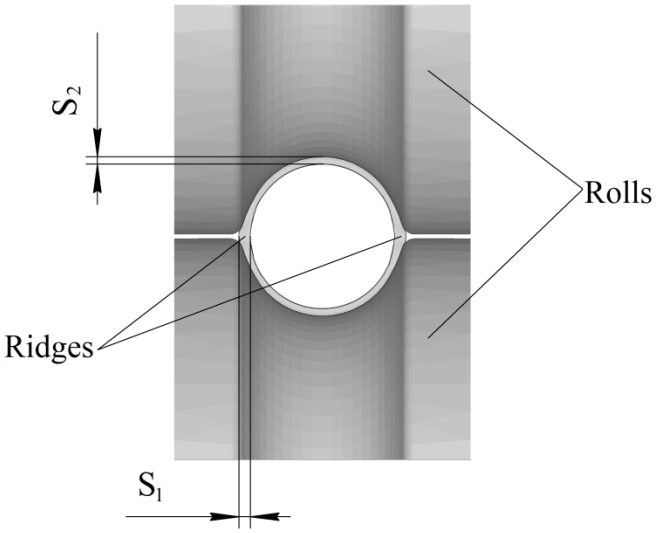

Figure 1. Cross-section of a pipe with ridges in the groove tapers after rolling at LRM-1.

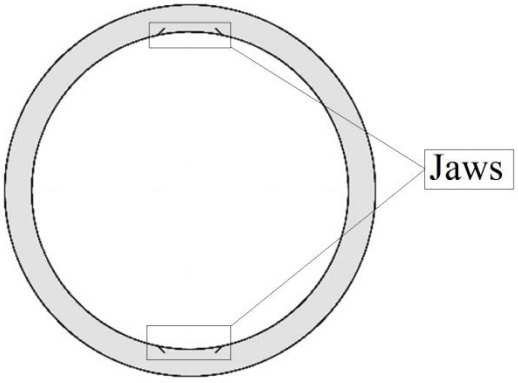

Figure 2. Jaws on the inner surface of the pipe.

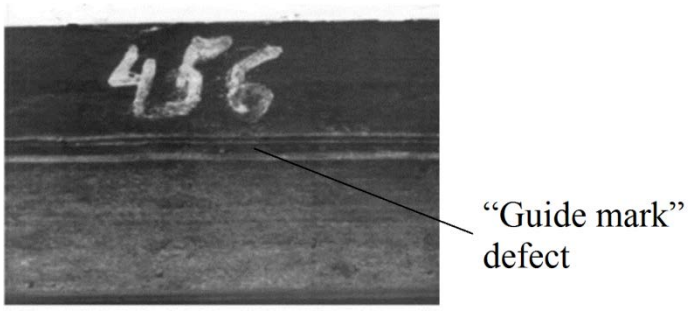

Figure 3. "Guide mark" defect on the inner surface of the pipe.

To study of the pipe metal shaping in the tops and tapers of the groove a dimensionless parameter was introduced S1/S2 (S1 and S2 are the wall thickness of the rough tube in the taper and top of the groove respectively), which characterizes the wall thickness variation of the pipe. In the course of the research [1] it was found that when S1/S2>1,8 a "guide mark" defect occurs on the inner surface of the pipe. In all computational experiments the rough tube temperature was assumed to be 1200 °C. On

the surface of the instrument boundary conditions were given as follows: the normal velocity component of the metal particles; friction law was given by Zibel. The index of the frictional forces of the operating rolls was assumed to be ψ=0,7 and ψ=0,2 on the mandrel - [7,8]. Roll rotation speed is assumed equal to 125 rpm. As the rough pipe material structural alloyed steel AISI-4140 was used. The speed of the pusher movement was assumed to be 60 mm/s. The diameter of the rough tube and the wall thickness were taken respectively equal 166 and 10 mm. The diameter of the pipe tube and the wall thickness were taken respectively equal 160 and 7 mm. Reduction ratio was assumed 1.4. The mandrel taper angle, grad ranged from 6 to 14 degrees.

Figure 4 shows the mandrel model of the LRM-1.

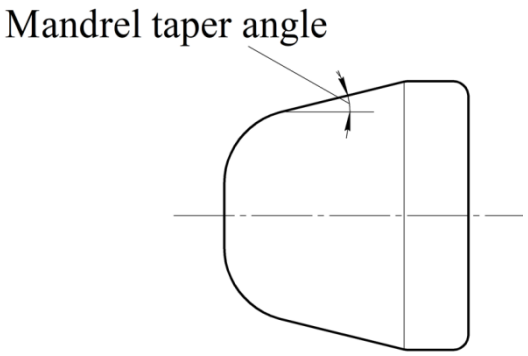

Figure 4. Mandrel model.

A three-dimensional model of the pipe rolling process in the “Deform” software is shown in figure 5.

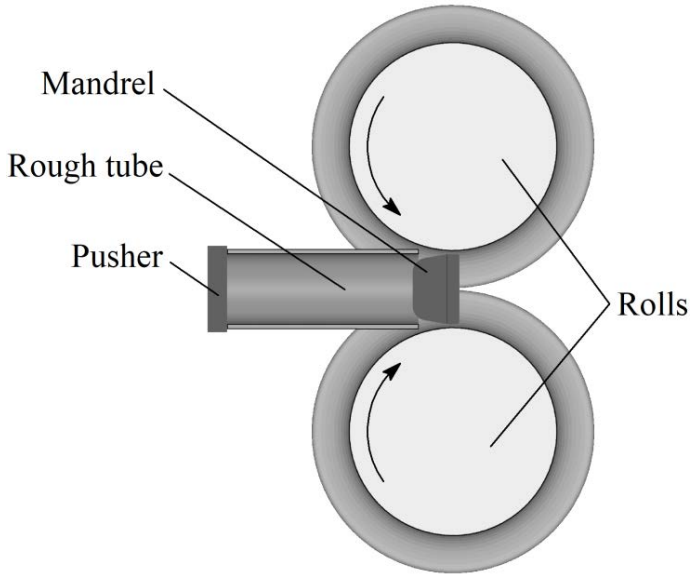

Figure 5. Three-dimensional model of the pipe rolling process.

In each computational experiment after the rolling on a stub mandrel process modeling the wall thickness was measured in the tapers S1 and tops of the groove S2, and then the averaged dimensionless parameter was calculated S1/S2. The results of the measurement are shown in figure 6.

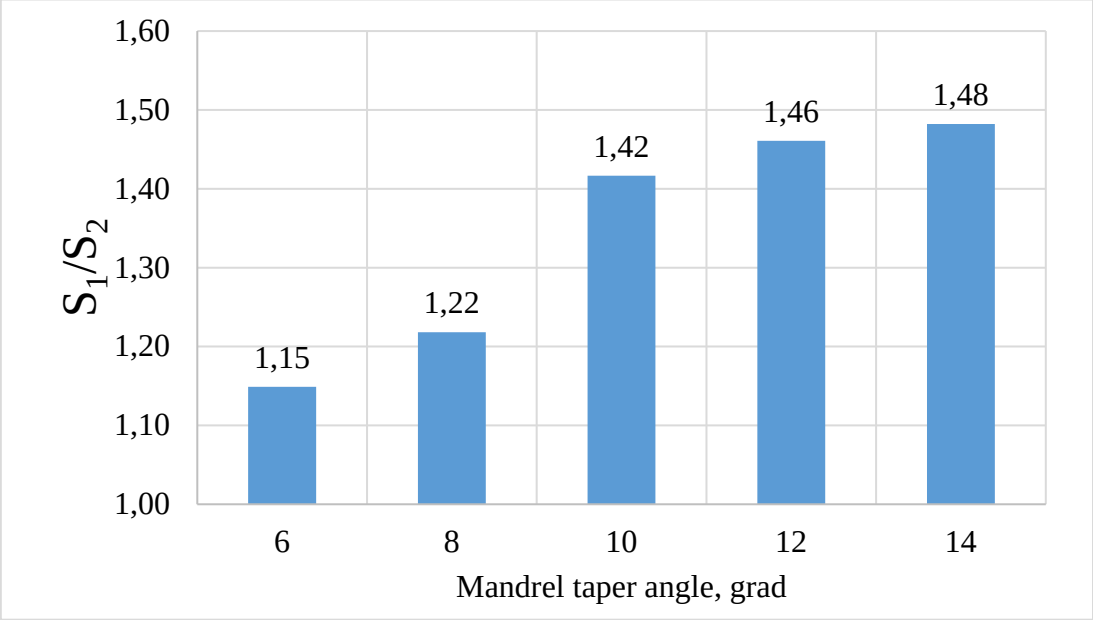

Figure 6. Dependence of the parameter S1/S2 from the mandrel taper angle.

Figure 6 show that with the taper angle increase from 6 to 14 degrees the dimensionless parameter S1/S2 increases from 1.15 to 1.48. Thus, with an increase of the mandrel taper angle the ridge size on the surface of the pipe increases and the probability of a “guide mark” defect on the inner surface of the pipe increases. It follows that it follows that pipe rolling on the automatic mill "tandem" should be carried out at low taper angles of the mandrel. It should also be noted that with a decrease in the taper angle of the mandrel, a decrease in the resistance forces on the mandrel and the condition for the capture of the pipe by the rolls improves.

3. Summary

Thus, during the study of the deformation of pipes made of steel AISI - 4140, the dependence of the pipe wall thickness variation on the calibration of the mandrel. A dimensionless parameter S1/S2 was measured, which characterizes the pipe metal shaping in the tapers and tops of the groove. It is established that with an increase of the taper angle from 6 to 14 degrees, the dimensionless parameter S1/S2 increases from 1.15 to 1.54. This leads to the fact that the size of the ridge on the surface of the pipe increases, the wall thickness variation of the pipe increases, and the probability of a “guide mark” defect formation on the inner surface of the pipe increases. Based on the results obtained, it can be concluded that when rolling pipes in a lengthwise rolling mill, mandrels with a reduced taper angle should be used. This reduces the pipe wall thickness variation and the tendency to form defects on the inner surface of the pipe.

Acknowledgements

This work was supported by a grant from the President of the Russian Federation for young scientists – candidates of sciences MK-1878.2020.8.

The study was made within the base part of state job in the field of scientific activity № 11.9538.2017/8.9. The work was supported by Act 211 Government of the Russian Federation, contract № 02. A03.21.0006.

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