An improved method for forming large diameter pipes with an enlarged wall based on the UOE process.

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Abstract: - The article deals with changing the scheme for forming large diameter pipes by introducing an additional deforming tool and describing the stages of forming.

Key-Words: - pipes of large diameter, UOE-process, forming, stress-strain state, plastic deformation

1 Introduction

Pipe industry is one of the main parts of the Russian industry which holds strong positions in the world market.

Despite the temporary decline in consumption volumes against the backdrop of geopolitical and global situation, the industry development tends have positive dynamics.

The main development is aimed at the implementation of such major projects as “Nord Stream”, “Nord Stream-2”, “Bovanenkovo-Ukhta-Torzhok”, the construction of which is carried out with the state support.

2 Problem Formulation

Taking into consideration that the pipelines are laid in the marine environment there is a tendency the pipe walls to be thickened. This is due to the aggressiveness of the environment and pressure increasing inside the pipelines to speed up the gas flow intensification.

One of the most productive processes of producing pipes is the so-called OUE-method. In consists of the following basic stages:

- edges forming by means of an edge former;
- bending the work-piece into a U-form by means of a preform molding press;
- bending the work-piece into an O-form by means of a final molding press.

Despite the high productivity of the method it obtains significant disadvantages as follows:

- The wall thickness of the produced pipe is limited by the capacity of the equipment used;
- The bend radius of the neutral surface changing in certain sections during the forming process from a U-form to an O-form, the deviations in the nature of the forming tool movement from ideal, and the existence of edge areas free from external forces crucially influence on the strain-stress state, and, as a consequence, contribute to occurrence of unformed sections.

Thus, the major limiting factor to increase the productivity of this method and expand the range of the produced tube size is the necessity to significantly promote the press forming load capacity, because the walls thickening leads to the need for pressure and equipment load increasing at the final stage.

Fig. 1 Process for the production of pipes

2.1 The existing method of pipe forming.

Let us consider it in more detail. Forming forces are communicated to the U-shaped work piece through the movable traverses with an upper die holder attached to them. At the final stages of the molding process the driving force passes from the six hydraulic cylinders paired between the traverses and architraves in each of the three constituent parts of the press. At these stages the forces closure occurs in 12 pre-tightened columns with a diameter of 600

mm, serving as guidelines for the movable traverses at the same time. During the series of earlier research and later numerous measurements of the movement patterns of certain parts and details a considerable number of deviations from the plane-parallel motion of the pipe-forming tool were detected. They significantly affect the uniformity of the key indicators of pipes being formed.

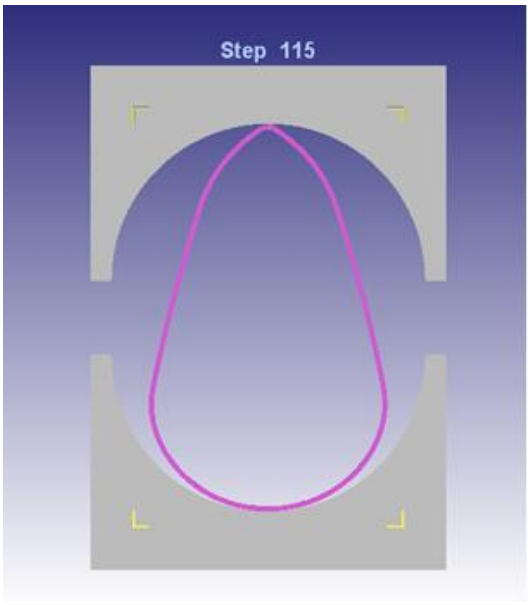

Fig. 2 Forming pipes at the first stage before the edges touch each other

At the first stage of the final molding process when the upper die is successively lowered (see Fig. 2), the work piece slides along the inner cylindrical surface with the appearance of a plastic hinge at the junction of the preformed bottom part into a straight section. This process is accompanied by insignificant internal stresses (except for the zone of the plastic hinge). The process lasts until the edges of the work piece come in contact with each other.
Thus, at this stage the distinctive features of pipes deformation are:
- slight elastic deformation of initial work piece straightened sections;
- Rapid growth of bending stresses in the transition area from the bottom semi-cylindrical part to the straightened side walls reaching plastification (the yield point),
-As the result of anti-bending of the form molding surface of the lower fixed metal blanks, filling the bent bottom sections of the U-shaped work piece with metal, accompanied by the originating and growth of tensile strength on the inner surface of the work piece at the tensometry points.

At the second stage with the further movement of the die, there comes a gradual ovalization of the straight section of the work piece from the zone of the plastic hinge to the side of the conjugate edges with the increasing of internal stresses. This process occurs before the dies contact with each other.
The distinctive features of this stage are:
- uneven shaping of the work piece, caused by the non-rigid construction of the upper die and the different edges height;
- the existence of the unformed sections of the work piece;
- the absence of uniform plastic deformation along the entire perimeter of the pipe.

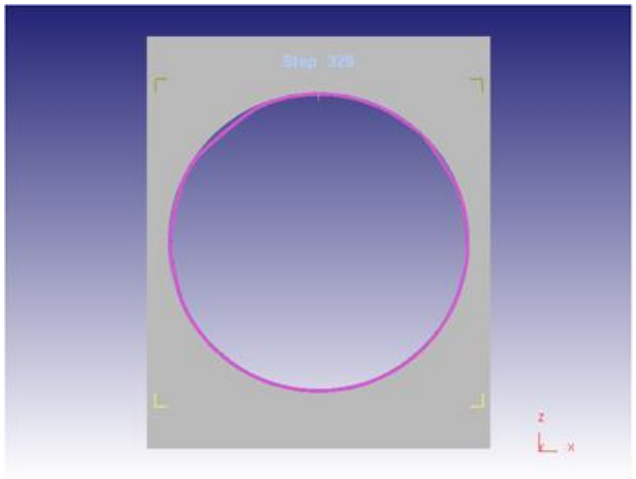

Fig. 3 Forming pipes at the last stage

The last stage of molding (see Fig. 3) is a rapid pressure increase in operating hydraulic cylinders in 1 - 1.5 s. up to 260 -300 atm (depending on the pipe dimensional characteristics) and keeping it for 4-8 seconds. After that the pressure is reduced to 5 atm and lifting, kicker hydraulic cylinders are switched on, releasing the die cavity to bring the next work piece into it. The purpose of this stage is to provide plastic deformation over the entire volume of the molded pipe.
To summarize the above said it is possible to single out the main disadvantages of the existing process of work piece shaping:
- the necessity of preparatory edge bending;
- the availability of straightened sections of the formed pipe in the zone of preparatory edge bending;
- the necessity of high pressure rolling at the final forming stage to achieve more flat plastic deformation along the entire perimeter. It prevents the wall thickening of the applicable work piece without the significant equipment modernization.

3 Problem Solution

Our research was aimed at a more detailed study of the final molding process by carrying out full-scale measurements and tests, studying the strain-stress state by the finite element method using the ANSIS and DEFORM software, resulting in the development of a new final molding method. The primary focus was on solving the issue of reducing molding forces to provide the possibility of the walls thickening of the pipes being formed.

The proposed solution of the method involves an additional deforming tool to be included in the existing molding scheme. The developed design of the internal tool does not prevent the free exit of the fabricated pipe from the final molding press and allows to form pipes of different sizes due to the possibility of its readjustment.

The first stage of molding starting from the moment of the upper die holder movement up to the moment when the edges of the work piece contact each other passes unchanged.

The second stage of forming begins with the contact of the edges of the work piece with each other (See Fig. 4). At this point the additional deforming tool located inside the work piece being molded starts to operate. This tool represents a system of movable rollers with the predetermined motion trajectory.

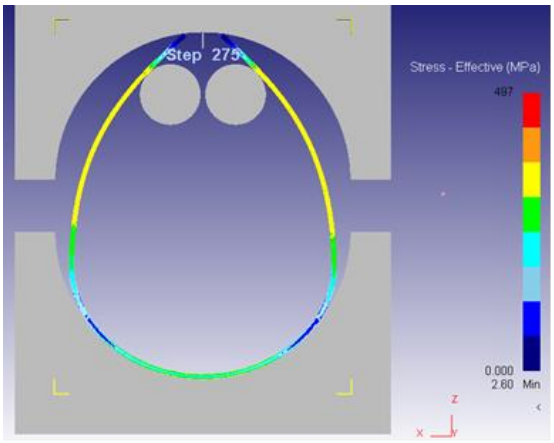

Fig. 4 Forming pipes using an additional tool

The contact of the rollers with the work piece starts from the area preceding the size of the bent edges. It is formed under the influence of normal stresses, which are caused by the contact of the work piece with the roller. At the subsequent lowering of the die, the roller forms the area from the place of preliminary hem bending to the side of the plastic hinge, changing the stress-strain state of the work piece. The figure shows that as the dies approach to each other the stresses in the work piece reach the yield point and, as a consequence, the plastic deformation of the work piece does not occur without high pressure.

4 Conclusion

Thus, the newly proposed final molding method has the following significant advantages:

- it does not require the changes of the existing equipment characteristics;
- it does not require high pressure rolling at the end of the final molding process to obtain plastic deformation of the pipe work piece;
- it does not demand the preparatory edge bending;
- the designed tool construction does not impede the fabricated pipe to leave the final molding press freely;
- the opportunity to widen the pipes size range without changing the press characteristics by means of tool readjustment.

To summarize, it can be noted that the usage of an additional deforming tool in the final molding process, the productivity of the process is increased. It allows to produce pipes of increased wall thickness and the time of the entire molding cycle is shortened.

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