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Rational form of pre-calibres at rolling of reinforcing steel

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ABSTRACT

Purpose: This work is devoted to definition of the most rational form of pre-calibers at rolling of reinforcing steel. The study was done using of computer modeling in the program “DEFORM-3D”.

Design/methodology/approach: For definition of rational forms of calibers were studied following calibers: one-radius oval, flat oval with double concavity and smooth barrel.

Findings: For the study as the basic parameters were chosen equivalent strain and deformation force. On the basis of comparative analysis of these parameters was revealed that the most rational form at rolling of reinforcing steel is pre-caliber in the form of flat oval with double concavity, because when rolling it in procurement is implemented the distribution of deformation in the horizontal to the vertical directions.

Research limitations/implications: In order to evaluate the impact of forms of pre-fine caliber on strain state, were made the single simulation, that is, the model is included only the pre-fine caliber.

Originality/value: Great interest is the shape and size of pre-fine calibers, after which metal gets to finish caliber, where is formed the final profile.

Keywords: Computer modeling; Reinforcing steel; Shape rolling

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METHODOLOGY OF RESEARCH, ANALYSIS AND MODELLING

1. Introduction

Reinforcing steel is used for reinforcement of ferroconcrete structures. In ferroconcrete structures it is established primarily for the perception of tension and strengthening of concrete in compressed zones of structures. Strength characteristics of the reinforcement depend on the chemical composition of steel (carbon, alloy additives) and the nature of its processing (hardening of steel by drawing, hood, flattening, heat treatment etc.). Despite the constant improvement of the rolling technology in the production of shape-rolled steel products are still high share of output of metal in marriage. In particular, at rolling reinforcing steel spread the geometric defect, as the lack of longitudinal or transverse ribs.

From work [1] it is known that for best filling any form of finishing calibers is necessary not only to ensure the accurate implementation of the geometric dimensions, but also, possibly, minimize the anisotropy of mechanical properties throughout the cross-section of deformable metal. If in the first case it is necessary only compliance with the requirements of GOST by sizes caliber with regard to thermal expansion of the metal, then to the second objective, certain challenges arise, as it is quite difficult to predict the distribution of the accumulated strain as for all the passages in the whole and for individual gauges. In particular, great interest is the shape and size of pre-fine calibers, after which metal gets to finish caliber, where is formed the final profile.

2. Preparation of model

For detailed study of the rolling process of reinforcing steel it was decided to conduct computer modeling in software DEFORM-3D. In works [1,2], were described the most rational, from the point of view of the authors, forms of pre-fine calibers for rolling of reinforcing steel. However, there is a controversial issue on the "transitional" profiles that some authors refer to small profiles, and others – to a large; in particular, a profile №20. For this profile as a pre-caliber offered as a one-radius oval and flat oval double concavity.

Also, in work [3] was proposed a new calibration for rolling of round and reinforcing steel, the main feature of which is pre-fine caliber made as smooth barrel. Therefore, to determine the most rational form of pre-fine caliber was decided to simulate the rolling of all three calibers in order to identify the most even distribution of the accumulated strain on billet's section.

Because the deformation is cumulative parameter, the analysis of the whole technological process is very difficult to track its change at any particular stage. Therefore, in order to evaluate the impact of forms of pre-fine caliber on strain state, were made the single simulation, that is, the model is included only the pre-fine caliber.

3. Results and discussion

In the result of simulation were received the following pictures of the strain distribution (Fig. 1).

For detailed study the strain distribution in the cross section was seen in two directions: vertical and horizontal, because before getting into finishing caliber billet in all three cases is turned on 90 degrees. It also reviewed the load of rolling arising from the deformation in these calibers, in order to assess whether changes the value of the load compared to the base value. The base value of the load was obtained in a one-radius oval, as this caliber is most widespread in shape mills, rolled reinforcing profiles.

3.1. One-radius oval

At rolling in caliber in the form of one-radius oval the distribution of strain proceeds is very uneven. At sufficiently uniform distribution in the axial zone (Fig. 2) while moving to the sides of the caliber values of strain are soared, particularly on sloping areas of metal. At the same time, on the lateral sides, where after turning is the formed transversal ribs, there is a significant decrease of the value of the deformation (Fig. 3).

In vertical distribution of strain is from 0.3195 to 0.3435 (dispersion of the values = 7.5%). In horizontal distribution of strain is from 0.3008 to 0.4248 (dispersion of the values = 41.2%). Considering sloping areas where the strain reaches a value of 0.5, dispersion is 66.2%.

At the graph of load are clearly visible two zones: in the first zone, describing the capture procurement load gradually increases as metal fills the deformation zone. With the steady rolling process value of the load remains at the same level and is about 251.5 kN (Fig. 4).

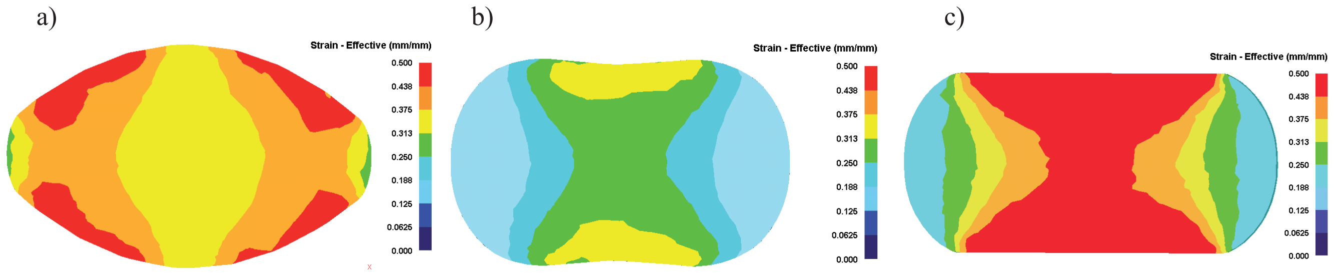

Fig. 1. Strain distribution: a) one-radius oval; b) flat oval with double concavity; c) smooth barrel

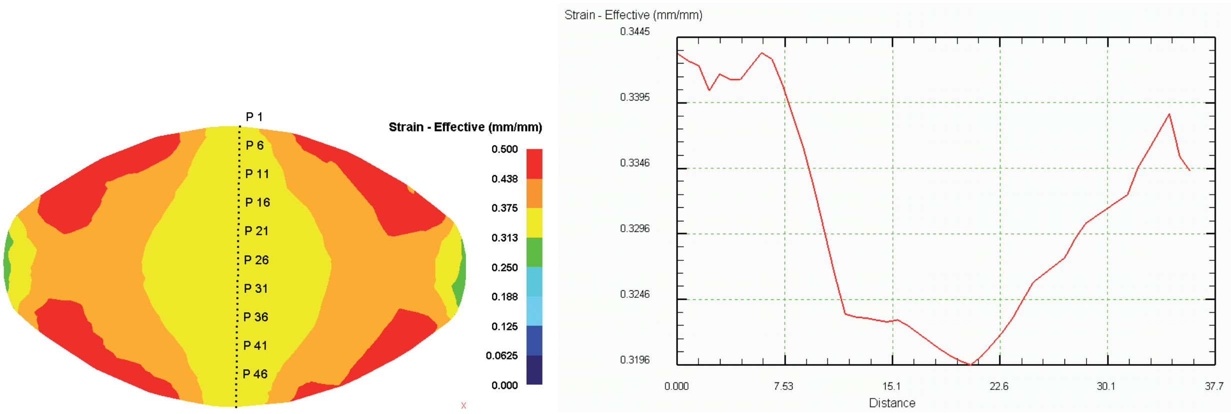

Fig. 2. Distribution of strain at one-radius oval in the vertical direction

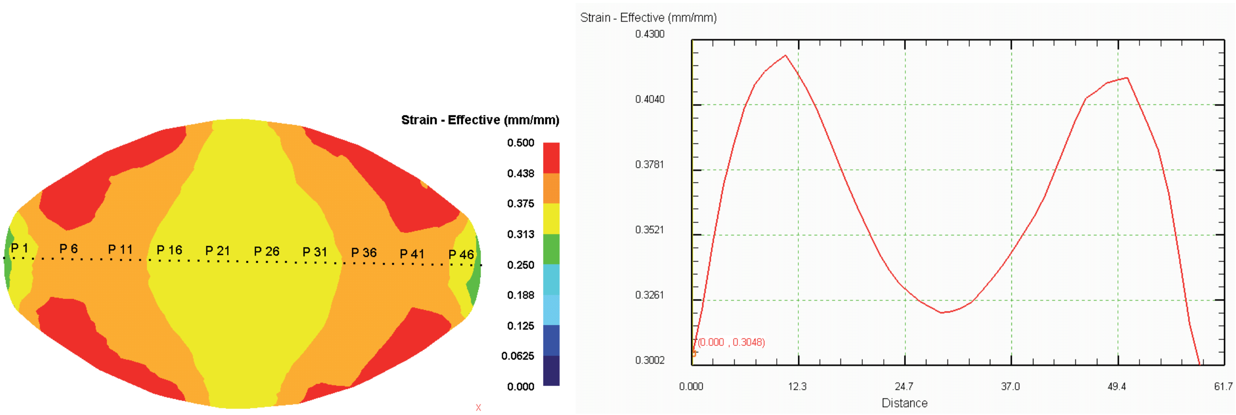

Fig. 3. Distribution of strain at one-radius oval in the horizontal direction

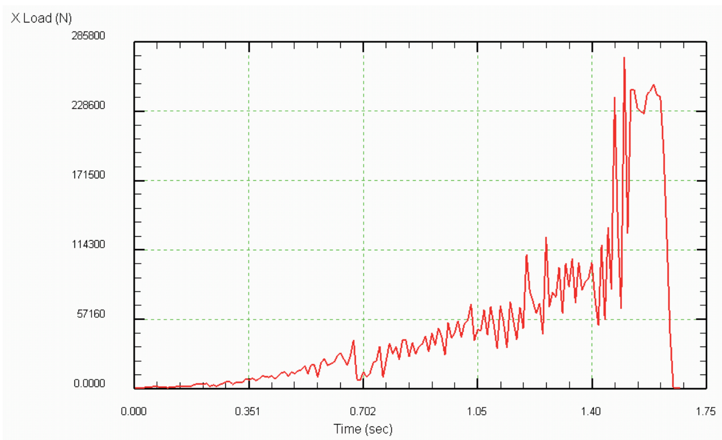

Fig. 4. Load at one-radius oval

3.2. Flat oval with double concavity

At rolling in calibers in the form of flat oval with double concavity the strain distribution in the vertical and horizontal directions is more even than in one-radius oval. In the axial zone, there was some increase of deformation by the concavity (Fig. 5). On the lateral sides, the strain distribution is more even than in one-radius oval (Fig. 6). This is confirmed graphics of strain distribution – in the first case clearly visible peaks characterizing the sharp increase then decrease and consequently – increase of the strain. In the second case the graph has more monotonous character.

In vertical distribution of strain is from 0.2784 to 0.3678 (dispersion of the values = 32.2%). In horizontal distribution of strain is from 0.1799 to 0.2512 (dispersion of the values = 39.6%).

In the graph of load, as in the first case, clearly visible two zones: zone capture of billet and zone of established rolling process, where the value of the load remains at the same level and is approximately 154.6 kN (Fig. 7).

3.3. Smooth barrel

When rolling on a smooth barrel the strain distribution in the vertical and horizontal directions runs very unevenly. At sufficiently uniform distribution in the axial zone (Fig. 8), when moving to the side ends, where contact of metal with rolls is missing, there is a significant decrease of the value of the strain (Fig. 9).

In vertical distribution of strain is from 0.4463 to 0.4705 (dispersion of the values = 5.4%). In horizontal distribution of strain is from 0.2249 to 0.4517 (dispersion of the values = 100.8%).

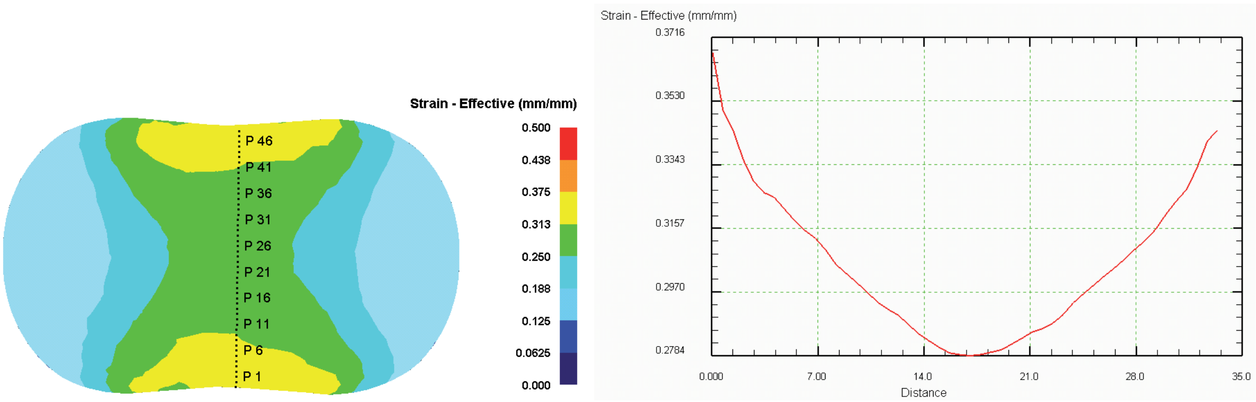

Fig. 5. Distribution of strain at flat oval in the vertical direction

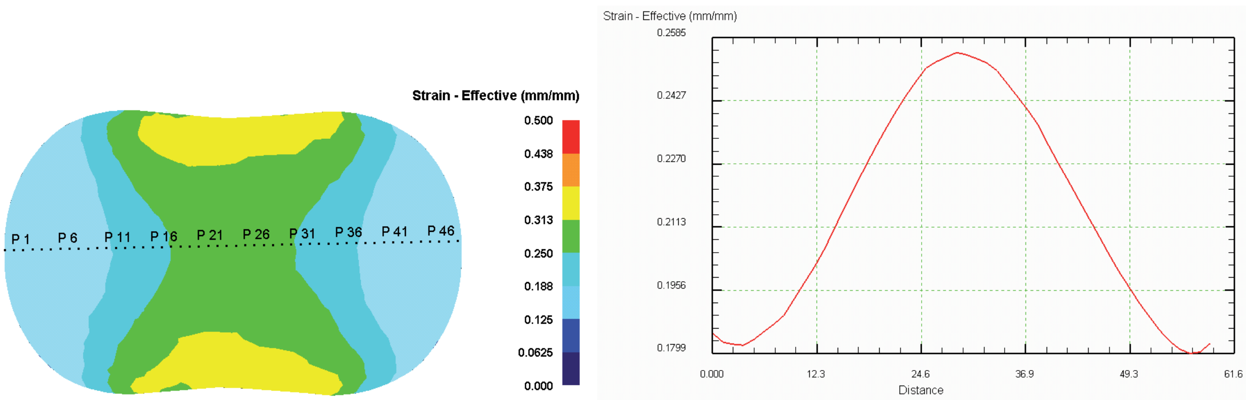

Fig. 6. Distribution of strain at flat oval in the horizontal direction

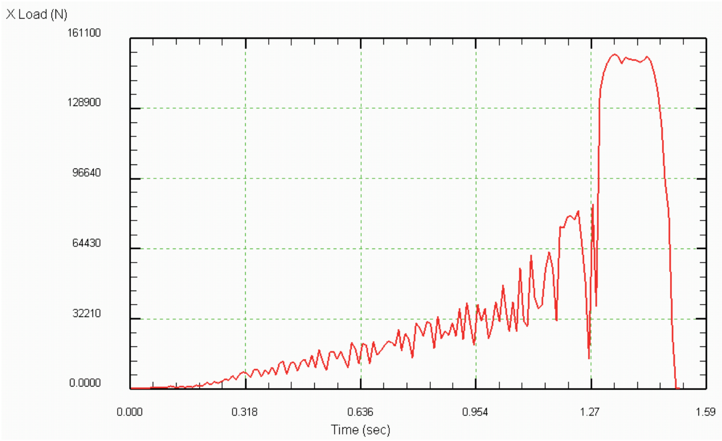

Fig. 7. Load at flat oval

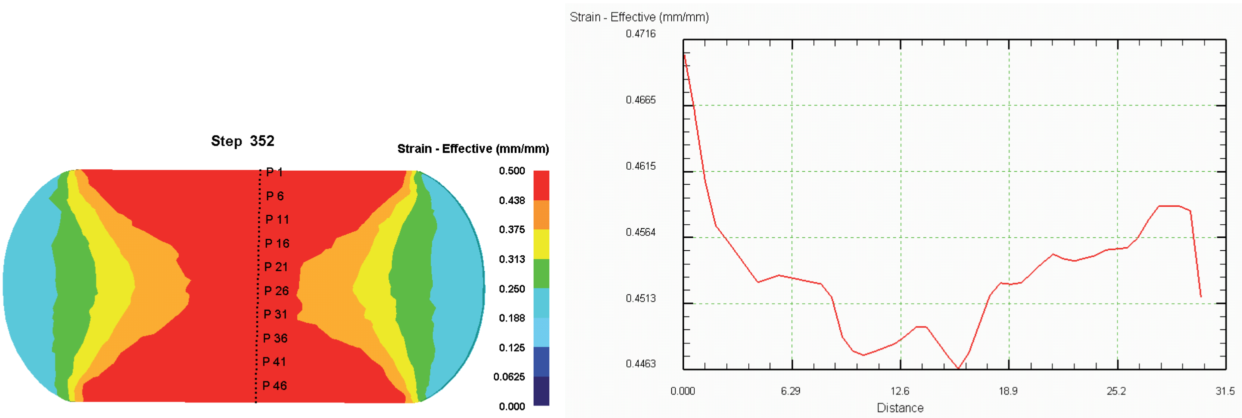

Fig. 8. Distribution of strain at rolling on a smooth barrel in the vertical direction

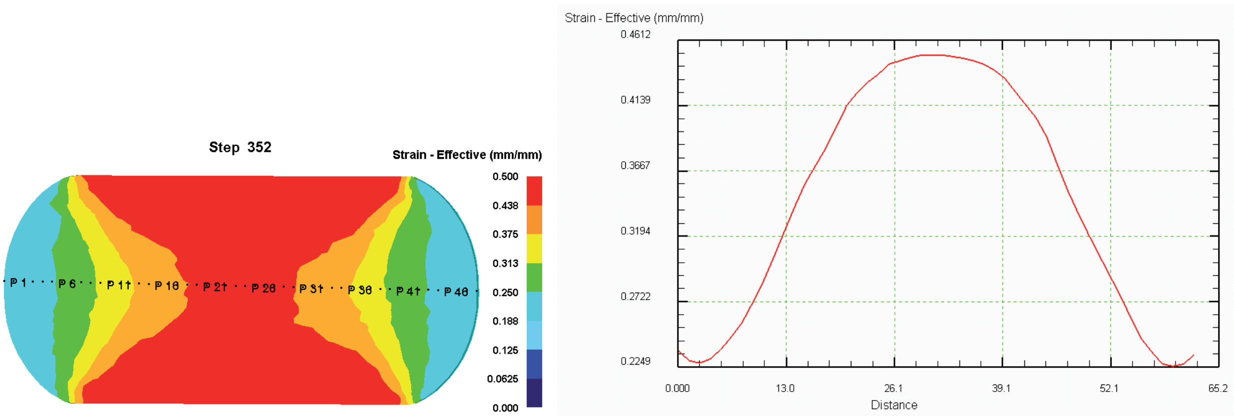

Fig. 9. Distribution of strain at rolling on a smooth barrel in the horizontal direction

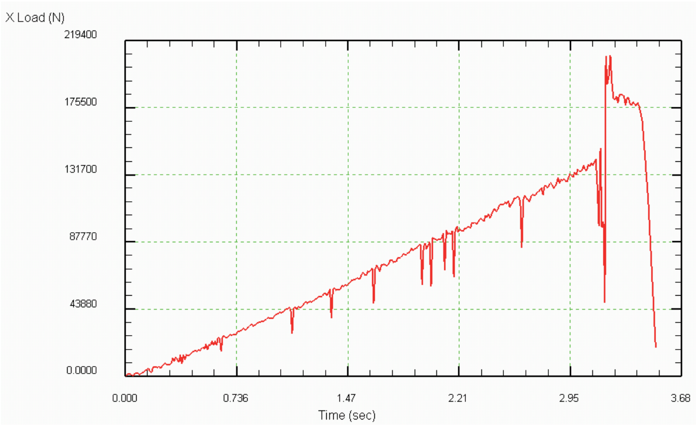

Fig. 10. Load at rolling on a smooth barrel

The graph of load, as discussed above calibers, has two zones. In the zone of steady-rolling process the load is about 184.3 kN (Fig. 10).

4. Conclusion

1) When rolling in all three versions of calibers the strain distribution is uneven in vertical and horizontal directions;
2) The most even distribution of deformation provides flat oval with double concavity in which dispersion of the values in vertical and horizontal directions is approximately the same; in the other two calibers the difference of the dispersions are quite significant;
3) Analysis of the load graphs had showed that values of load at rolling in a flat oval and on the smooth barrel don't exceed a value for one-radius oval that says about the possibility of using these calibers on existing equipment without its modernization.

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