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The Deformation Zone Geometrical Factors and its Influence on Deformation Shift Degree for the Axial Zone of Rolled High Bars

B. Sereda, I. Kruglyak., A. Kovalenko, D. Sereda, T. Vasilchenko

Dept. of Material Science & Metal Forming, Zaporizhzhzya State Engineering Academy, Zaporizhzhya, Ukraine

Data storage about characteristics of the tensely-deformed condition of the rolling metal for various combinations of the geometrical factors for the deformation zone while using results of the planned experiments is reasonable to carry them out, approximating them in the view of regressional differences. During seven-factorial experiment the Λ plasticity criterion was founded. Results of approximation of one of the basic integrated indicators degree the deformation of an axial zone shift of depending on geometrical factors of the deformation have been considered. It is received that the greatest influence on Λ in the investigated interval of the variation for deformation zone factors renders relative cogging of samples. The given models can be used by development work of reduction modes and blooming of thick sheet rolling mills providing intensive development of metal structure and (or) the minimum probability defect production as a result of its discontinuity.

Keywords: ROLLING, BAR, FACTOR, DEFORMATION, DEFORMATION SHIFT DEGREE

Introduction

Data storage about characteristics of the tensely-deformed condition of the rolling metal for various combinations of the geometrical factors for the deformation zone while using results of the planned experiments is reasonable to carry them out, approximating them in the view of regressional differences. This data presentation form has a number of advantages. First of all the data approximated thus can be used in mathematical models of the rolling process. Secondly, in this case it is easy to define the influence degree of the every factor according to the value of factors and also it is easy to define the influence degree of mixed factors on investigated function of the process. And besides the graphic display of dependences in the form of response surfaces visually represents regularity of change functions in the multidimensional factorial space [1].

Results of approximation of one of the basic integrated indicators degree the deformation of an axial zone shift of depending on geometrical factors of the deformation are have been considered. Proceeding from the physical meaning and results of made research investigations before change A for samples rolled on a flat body received as a result or processing information of seven-factorial experiment we have displayed a polynom of the second order:

$$\begin{aligned}\Lambda = 2{,}86 + 3{,}69x_1^2 + 0{,}03x_3^2 + 1{,}92x_4^2 - 0{,}29x_6^2 + 0{,}08x_7^2 +\\ + 2{,}03x_1 - 1{,}01x_1 \cdot x_4 - 0{,}8x_2 - 0{,}31x_1 \cdot x_7 + 0{,}71x_2 \cdot x_4 +\\ + 0{,}23x_1 \cdot x_6 + 0{,}01x_3 \cdot x_7 - 4{,}73x_4 - 0{,}03x_5 + 0{,}04x_4 \cdot x_5.\end{aligned} \quad \text{(Eq. 1)}$$

Where $x_1 = \varepsilon$; $x_2 = h_0/D$; $x_3 = b_0/h_0$; $x_4 = b_0/l$; $x_5 = \beta/10$, degree; $x_6 = \Delta f_B/h_0 \cdot 10$; $x_7 = \Delta f_T/h_0 \cdot 10$

The expression adequately reflects the change A in ranges of change of geometrical factors of the deformation zone of. The standard deviation of the approximated data from the experimental date has made 0,045 at the maximum deviation 0,15. Adequacy of expression (equation (1)) for experimental data follows up from this, that in the considered case the relation of inadequacy dispersion to the dispersion ofthe experience is less thanthe tabulated value of Fisher criterion for 5 % of a significant value [2].

It is received that the greatest influence on Λ in the investigated interval of the variation for deformation zone factors renders relative cogging of samples. For the case of samples for rolling of initial square cross-section on a flat body of roll from 0,00 to 0,30 causes the increasing Λ from zero to 0,70 (**Figure 1**).

For low feed rolling (h_0/D = 0,18) Λ is more than for high feed (h_0/D = 0,78) for 0,1 that explains the maximum redistribution of the cumulative pre-contact deformations in the central layers of metal at reduction relation h_0/D. The width increase of the bar at its constant height causes the growth Λ: in the variation range b_0/h_0 from 0,5 to 1,5 Λ changes for 0,1 (**Figure 2**).The influence of b_0/h_0 on Λ unlike h_0/D has nonlinear characteristics (**Figure 3**) that in need of the degree increasing of the shifting deformation in an axial zone of feed assumes the increased values achievement b_0/h_0, i.e. usage of a technological method of the rolling bar.

Thus, at a cogged ingot rolling of initial rectangular section the directed variation of h_0/D and b_0/h_0 provides additional change Λ on 15…25 % that is essential at definition of conditions of intensive workup of the metal structure.

Searching for additional reserves in the intensification process of high bars rolling has defined the usage of shaping of rolls for blooming with the aim of possible increasing Λ. Profiling of rolls was characterized by two factors: β and b_0/l. The influence of these factors on the degree size of deformation of an axial zone shifting feed rolling has been investigated for ε = 0,15 and various configurations of cross-section section cogged ingot rolling. It is received that for a case of high narrow bar rolling (h_0/D = 0,8 and b_0/h_0 = 0,5) the increase Λ with increasing b_0/l (**Figure 4**), reaching for b_0/l = 1,3 in comparison with b_0/l = 1,0 50 % is characteristic. Noted growth Λ is caused by features of metal plastic current which in this case is characterized by a tendency to intensive widening pre-contact layers of a cogged ingot rolling and increasing with growth b_0/l supporting with the action of inclined sites of flat rolls. The increase of an angle of slope β of these sites and increasing b_0/l causes the redistribution of metal plastic current with increasing in its intensity in an axial zone of rolling.

For the observed case the usage of shaping of rolls with b_0/l=1,25…1,30 at β = 8…with influence degree on Λ is equivalent to the increasing of the bar width with b_0/h_0 = 0,5 till b_0/h_0 = 1,5.

Reduction of a bar height to h_0/D = 0,5 and increasing b_0/h_0 = 0,1 leads to character change of metal form changing in the rolling and as consequence – to reduction Λ (**Figure 5**) as in this case non-uniformity of metal plastic flow between a metal axial zone and metal volumes adjoining to the lateral sides of cogged ingot rolling sharply increases. Here the reduction in thickness of the central zone on width decreases at constant resulted reduction and accordingly during the increasing of reduction of lateral sites of cogged ingot rolling. The further growth b_0/l as well as at cogged ingot rolling on flat rolls increases Λ in all range of a variation β and b_0/l (**Figure 6**). The minimum difference between values Λ for cogged ingot rolling cases with b_0/l = 0,3 and b_0/l = 1,3 is observed for h_0/D = 0,2 (**Figure 7**).

Consequently, the presence of rolls profiling encourage the increasing Λ only for high bars and decreases the degree for shift deformation in the axial zone of the rolling at decreasing h_0/D. The effect of an angle β on Λ changing is shown poorly.

Rolling of high bars is accompanied by distortion of initial rectangular cross-section cogged ingot rolling. The results of the experimental data processing characterize the essential influence on changing Λ of configuration of lateral sides. It is received that the greatest value Λ accepts at flat lateral sides. Presence on lateral sides for single or double roll body forming sharply reduces the degree deformation of the shift in an axial zone. it is significant that for high and narrow cogged ingot (**Figure 8**), and also for low wide bars (**Figure 9**).The change of factors h_0/D (**Figure 10** and **Figure 8**), b_0/h_0 (**Figure 10** and **Figure 11**) and relative reduction ε (**Figure 10** and **Figure 12**) only increases on decreases the level Λ. Therefore from achieved positions of maximum values Λ it is reasonable to provide in each pass a configuration of lateral sides of the rolled ingot, close to the flat one on that assumes alternate reduction of stock rolling in horizontal and vertical rolls with achievement of considerable excess of current width of the stock rolling over its height.

The increase in camber of contact surfaces of cogged ingot rolling in the investigated range does not exceed level Λ as at constant resulted cogging the deformation influence decreases for angular zones of cogged ingot rolling. Moreover, at factor change $\Delta f_T/b_0$ from-0,05 to 0,00 Λ even decreases (**Figure 11**) as in the first case the cogged ingot rolling of configuration promotes in creasing of intensity of plastic flow of metal from a corner to the centre, and in the second case – it is not present. The analysis of expression (1) shows that only at extrapolation of values $\Delta f_T/b_0$ to size 0,10 it is possible to increase level Λ on 0,08.

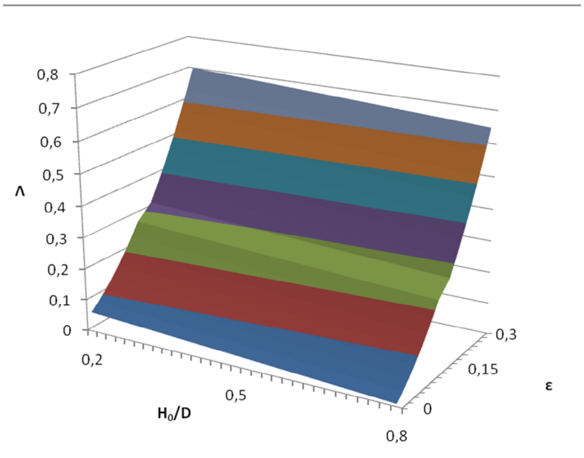

Figure 1. The influence of relative reduction and a factor h_0/D on Λ at rolling on a flat body of rolls $b_0/h_0 = 1$; $b_0/l = 1$; $\beta = 0$; $\Delta f_B/h_0 = 0$; $\Delta f_\Gamma/b_0 = 0$

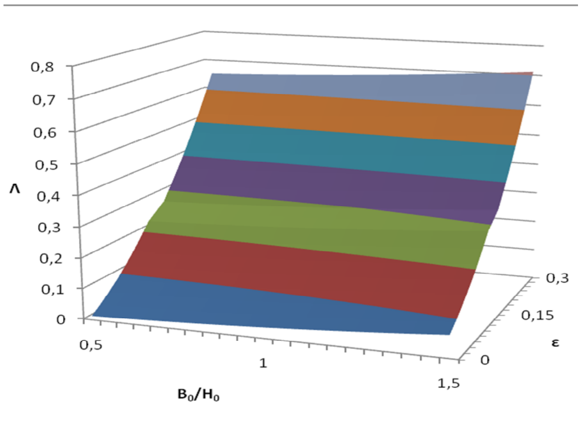

Figure 2. The influence of factors ε andb_0/h_0on Λat rolling on a flat body of rolls $h_0/D = 0{,}5$; $b_0/l = 1$; $\beta = 0$; $\Delta f_B/h_0 = 0$; $\Delta f_\Gamma/b_0 = 0$

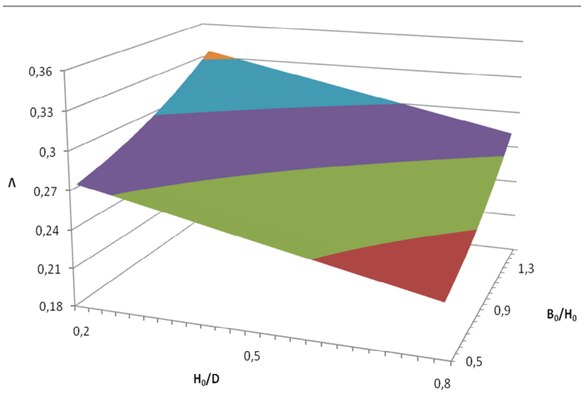

Figure 3. The influence of factors h_0/D and b_0/h_0 at rolling on a flat body of rolls $\varepsilon = 0{,}15$; $b_0/l = 1$; $\beta = 0$; $\Delta f_B/h_0 = 0$; $\Delta f_\Gamma/b_0 = 0$

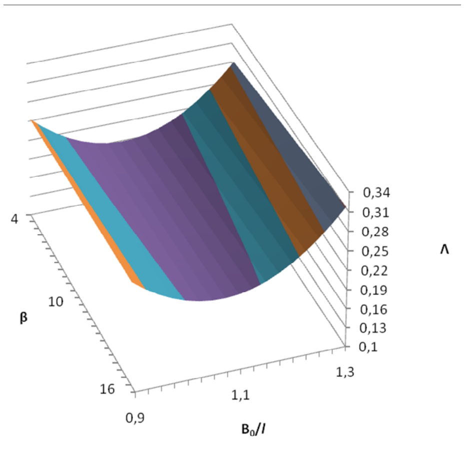

Figure 4. The influence of working surface profiling of a flat body of rolls $\varepsilon = 0{,}15$;$h_0/D = 1$; $b_0/h_0 = 0{,}5$; $\Delta f_B/h_0 = 0$; $\Delta f_\Gamma/b_0 = 0$

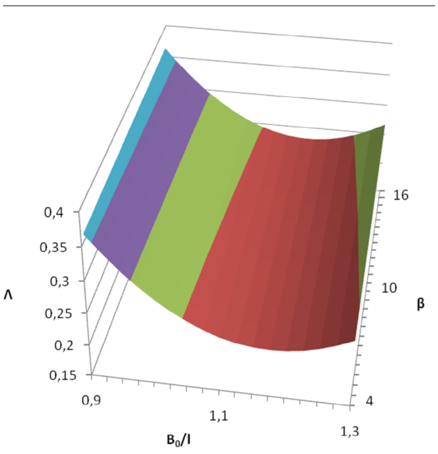

Figure 5. The influence of a working surface profiling of a flat body of rolls on Λ ($\varepsilon = 0{,}15$; $h_0/D = 0{,}5$; $b_0/h_0= 1$; $\Delta f_B/h_0= 0$; $\Delta f_\Gamma/b_0 = 0$)

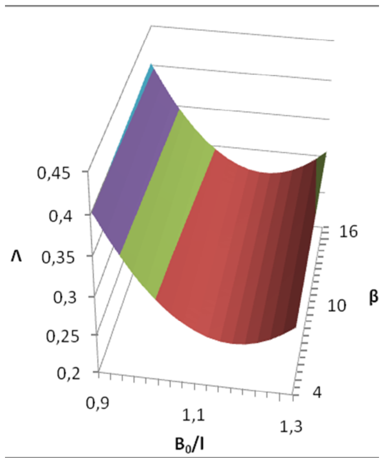

Figure 6. The influence of a working surface profiling of a flat body of rolls on Λ ($\varepsilon = 0{,}15$; $h_0/D = 0{,}5$; $b_0/h_0 = 1{,}5$; $\Delta f_B/h_0 = 0$; $\Delta f_\Gamma/b_0 = 0$)

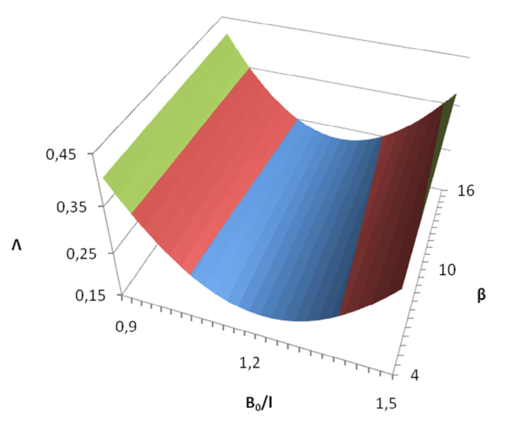

Figure 7. The influence of a working surface profiling of a flat body of rolls on Λ (ε = 0,15; $h_0/D = 0,2$; $b_0/h_0 = 1$; $\Delta f_B/h_0 = 0$; $\Delta f_Г/b_0 = 0$)

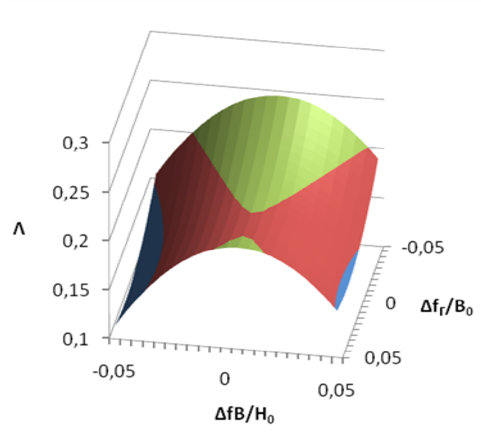

Figure 8. The influence of cross-section bar on Λ at rolled stock on a flat body of rolls (ε = 0,15; $h_0/D = 1$; $b_0/h_0 = 0,5$; $b_0/l = 1$; β = 0)

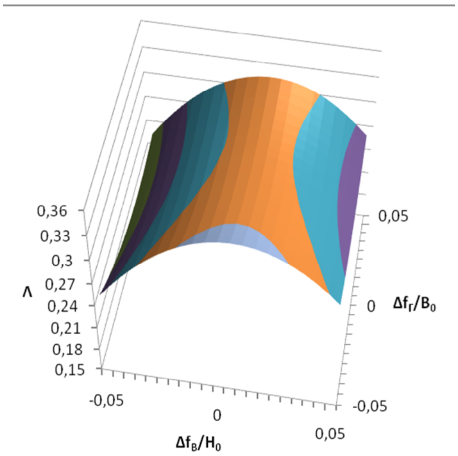

Figure 9. The influence of cross-section bar on Λ at rolled stock on a flat body of rolls (ε = 0,15; $h_0/D = 0,5$; $b_0/h_0 = 1,5$; $b_0/l = 1$; β = 0)

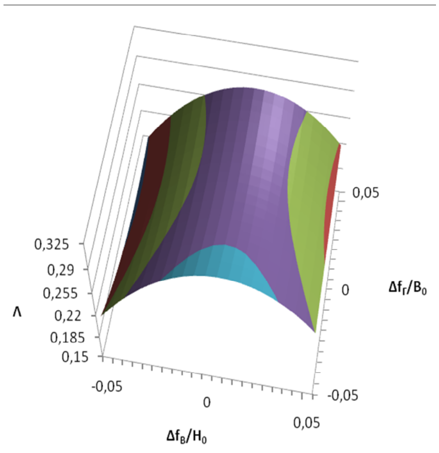

Figure 10. The Influence of configuration of cross-section section of the bar on Λ at a flat body of rolls (ε = 0,15; $h_0/D = 0,5$; $b_0/h_0 = 1$; $b_0/l = 1$; β = 0)

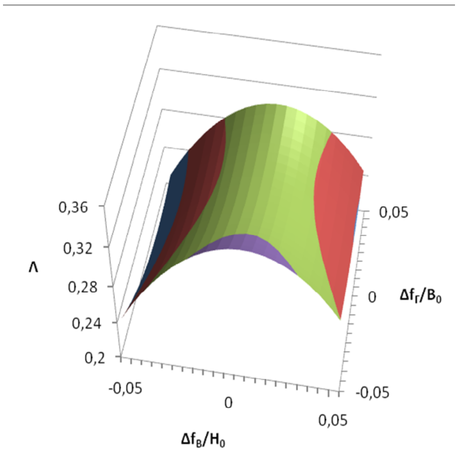

Figure 11. The Influence of configuration of the cross-section bar on Λ at rolling on a flat body of rolls (ε = 0,15; $h_0/D = 0,2$; $b_0/h_0 = 1$; $b_0/l = 1$; β = 0)

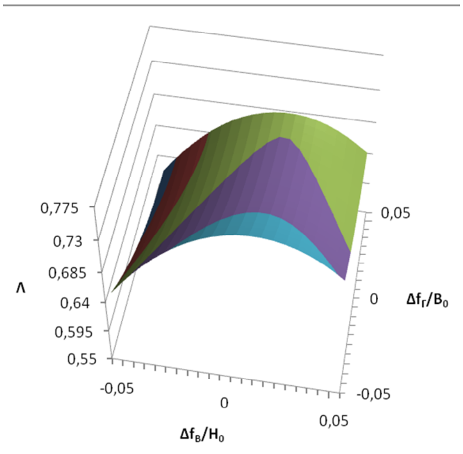

Figure 12. The Influence of configuration of the cross-section bar on Λ at a flat body of rolls (ε = 0,3; $h_0/D = 0,5$; $b_0/h_0 = 1$; $b_0/l = 1$; β = 0)

Conclusions

The complete analysis of changing of all primary experimental data characteristics of the intense-deformed condition of metal received as a result of processing depending on values of geometrical factors of the deformation zone, including defining local features of plastic flow of metal, has confirmed the correctness of usage of experimental and theoretical approach for the decision of a three-dimensional plastic flow of metal problem.

The given models can be used by development work of reduction modes and blooming of thick sheet rolling mills providing intensive development of metal structure and (or) the minimum probability defect production as a result of its discontinuity.

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Геометрические параметры очага деформации и их влияние на степень деформации для осевой зоны катаного прутка

Середа Б., Кругляк И., Коваленко А.,
Середа Д., Васильченко Т.

Эксперименты по определению данных о характеристиках напряженно-деформированного состояния проката для различных сочетаний геометрических факторов очага деформации целесообразно проводить, приводя их к виду регрессионной разности. В ходе проведения семифакторного эксперимента был обоснован критерий пластичности Λ. Получены результаты зависимости одного из комплексных показателей степени деформации в осевой зоне от геометрических факторов деформации. Определено, что огромное влияние на Λ в исследованном диапазоне изменения факторов очага деформации оказывает относительное обжатие образцов. Данная модель может быть использована для дальнейшего улучшения режимов обжатия блюмингов и толстолистовых станов в случае интенсивного улучшения структуры металла и (или) минимально возможного количества брака от прерываний процесса.

