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Investigation of Tool Shape Effect on Deformation Unhomogeneity under Free Upsetting of Rail Wheel Blanks

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There are presented the results of theoretical studies of upsetting process using software forge3 and the simultaneous flattening of wheel blank using conical punch of 630 mm in outer diameter, with a flat section at the end of 50, 250 and 450 mm in diameter and tilt angle of generatix to the horizontal of 5, 10, 15 and 25 °.

Keywords: FORGING, BLANK, UPSETTING, TOOL, DISK, LEDGE, FORGED PIECE, RING

Introduction

Investigation of strain distribution regularities in metal forming processes is of current interest for both optimization of these processes to reduce operating expenses and for product quality improvement.

Bun flattening by stamping punch of various shape is often used in the processes of railway wheel blank upsetting. Thus it is difficult to define the way of blank outside diameter change at free upsetting which is important for the subsequent stage of press forming of full-profile blank. Besides, the shape of stamping punch back defines the pattern of metal flow at the subsequent stage of blank forming in closed dies which configuration is defined by technological features of railway-wheel mill.

In similar research the issues of strain distribution in the blank body depending on stamp tool configuration are considered mainly on the instances of stamping punch pressing with diameter 4-6 times smaller than the blank diameter and various shape of the back in elasto-plastic medium [1, 2]. Because of significant effect of external zones on strain distribution pattern in the radial directionm, the results of such investigations are reliable enough and need to be specified in case of blank upsetting by stamping punch with diameter considerably more than its initial diameter (in particular, conclusion about that strain distribution pattern in the radial direction almost does not depend on stamping punch end configuration [1]).

The task of present research is to study tool shape effect on unhomogeneity of deformation at free upsetting and decrease of finished product excentricity.

Results and Discussion

For more detailes concerning the pattern of logarithmic deformation values distribution across wheel blank section after upsetting by press tools in the form of flattened cone, we carried out simulation of wheel production process with diameter of 957 mm according to GOST 10791-2004 from cylindrical blank with diameter of 482 mm for the real industrial conditions using software forge3.

Simulation is accomplished for several options of upsetting process and simultaneous blank flattening with the use of conic stamping punches

with outside diameter of 630 mm and flat section on the back of 50, 250 and 450 mm in diameter with a tilt angle of generatix to the horizontal 5, 10, 15 and 25 ° (**Figure 1**).

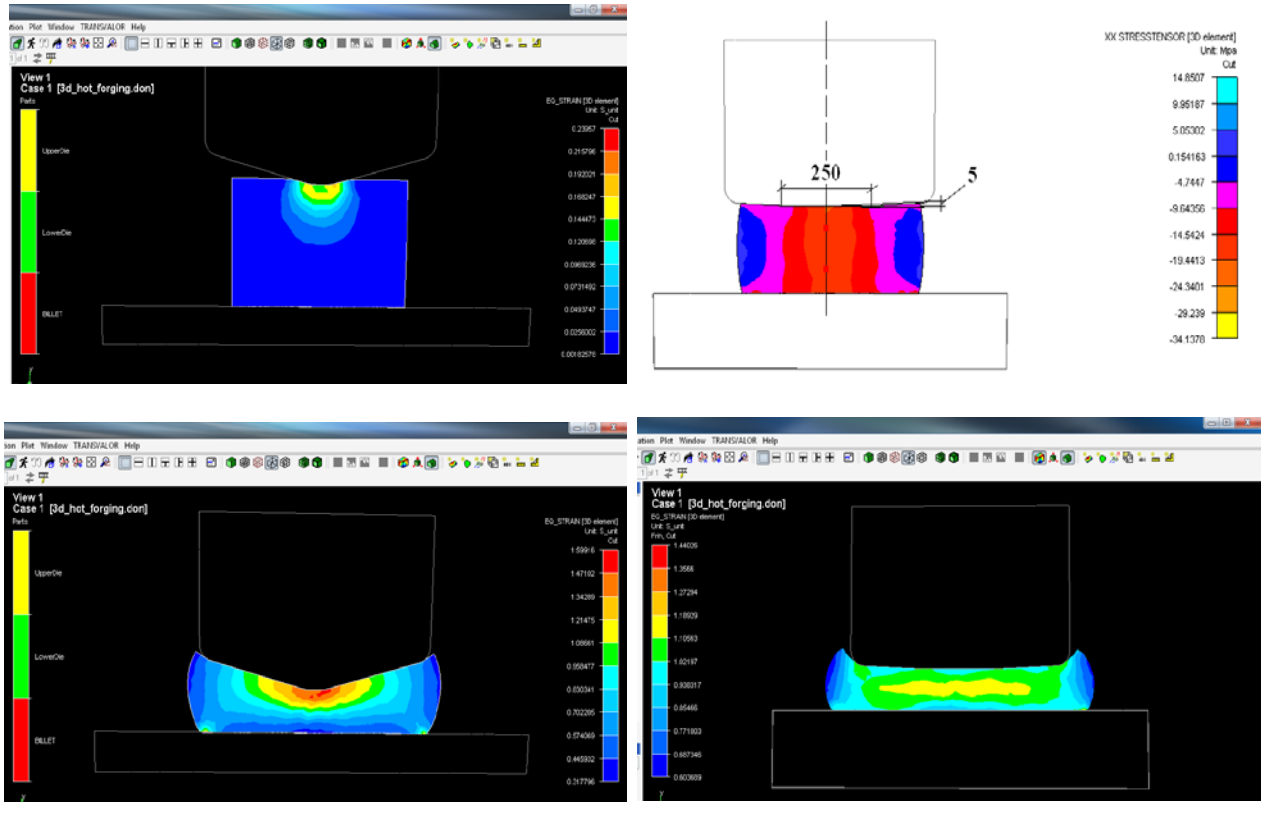
According to investigation conditions, the blanks are upset on the final altitude with equal amount of reduction. Thus in each case the amount of reduction (e) in the radial direction is defined on the greatest diameter with step on axes X equal to 30 mm and also min and max values of amount of reduction e_{min} and e_{max}. According to obtained values e_{min} and e_{max} unhomogeneity of deformation Δe is defined as $\Delta e = e_{max} - e_{min}$. The results obtained by simulation method are shown in **Figure 2** and **3**.

As shown in **Figure 2**, with α angle increase the maximum value of deformation (e_{max}) in X-direction grows. Deformation maxima depend on diameter of punch flat section at the back. Thus value e_{max} increases within the limits of 1.15-1.45 with decrease of flat section diameter.

It follows from **Figure 3** that with α angle increase the value of deformation unhomogeneity grows in the radial direction in all cases. The less diameter of stamping punch end flat section, the more value of deformation unhomogeneity for equal angles α. Previous investigations into effect of stamp tool shape on the out-of-roundness of cylindrical plumbeous samples after their upsetting by punches in the form of flattened cone showed that:

- increase of punch α angle led to significant growth of out-of-roundness value of upset sample ($\Delta D_{av.}$) with simultaneous decrease of its diameter;
- decrease of flat section diameter at equal angles α led to similar results [3].

Thus, it is possible to draw a conclusion about dependence of cylindrical blank out-of-roundness after its free upsetting on the values of deformation unhomogeneity in the radial direction. The more value of deformation unhomogeneity, the more out-of-roundness of the blank.



a b

Figure 1. Wheel blank upsetting by stamping punch with a flat section at the back with diameter of 50 mm (*a*), 250 mm (*b*) and tilt angle of generatix to the horizontal 15 ° (*a*) and 5 ° (*b*)

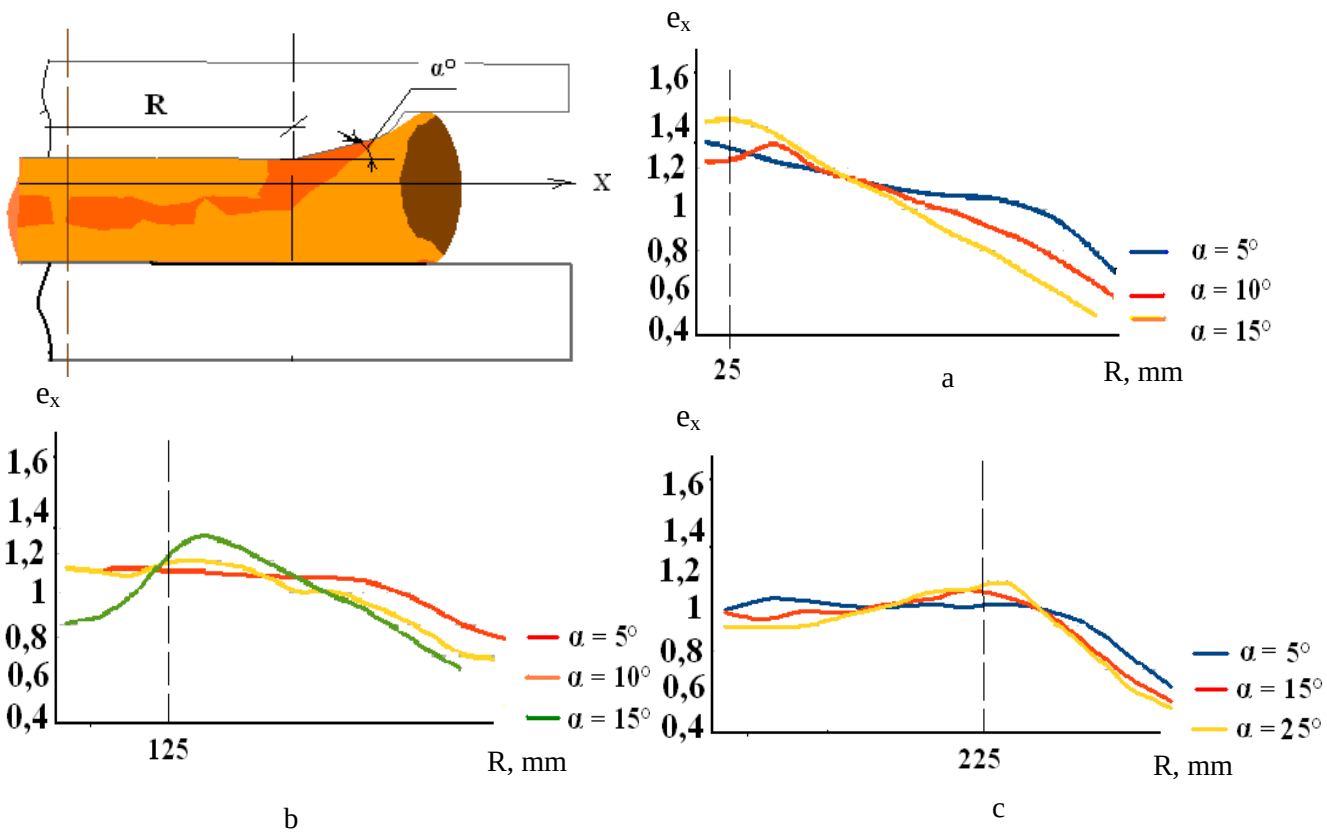


Figure 2. Strain distribution pattern in the radial direction in the upset blank body by stamping punch with a flat section in diameter, mm: *a* - 50; *b* - 250; *c* – 450

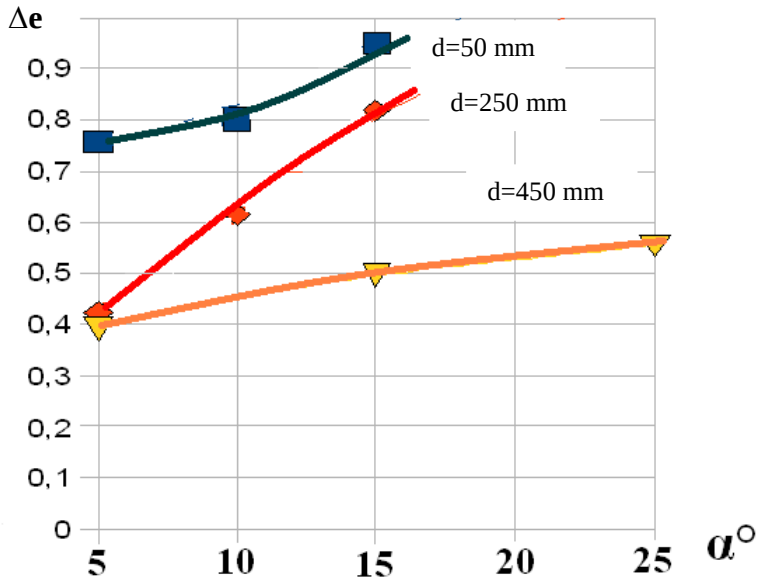


Figure 3. Dependence of deformation unhomogeneity in the radial direction on conic punch generator tilt angle to horizontal and its flat section diameter

Conclusions

1.The regularities of local strain distribution in the radial direction in cylindrical blank after upsetting by various configuration tool are determined by means of computer simulation. It is shown that strain distribution pattern in the blank body in the radial direction is defined by the press tool shape.

2.Dependences of deformation unhomogeneity degree on tool shape are determined. With α angle increase the value of deformation unhomogeneity in the radial direction grows in all cases. The less diameter of punch back flat section, the more deformation unhomogeneity for equal angles α. Value e_{max} increases within the limits of 1.15-1.45 with decrease of flat section diameter 50-450 mm.

3.Dependence of out-of-roundness of cylindrical blank during upsetting on deformation unhomogeneity in the radial direction is shown. The more deformation unhomogeneity, the more out-of-roundness of the blank.

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Исследование влияния формы инструмента на неравномерность деформации при свободной осадке заготовок железнодорожных колес

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В работе представлены результаты теоретических исследований с использованием программного обеспечения forge3 процесса осадки и одновременной разгонки колесной заготовки с использованием конических пуансонов наружным диаметром 630 мм, имеющих плоский участок на торце диаметром 50, 250 и 450 мм с углом наклона образующей к горизонтали 5, 10, 15 и 25°.