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Selection of Process Scheme for Multiple-Stage Forming of Railway Wheel Blanks

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Presented scheme of wheel blank forming is more rational and provides higher mechanical characteristics of metal in the center of tread and in the wheel hub.

Keywords: SCHEME, MULTIPLE-STAGE FORMING, BLANK, RAILWAY WHEEL

Introduction

The issues related to the manufacture of high-quality products at minimum costs have recently become especially urgent among manufacturers of the former Soviet republics. These issues are of current concern also for solid wheel manufacturers at JSC "INTERPIPE NTZ" (Ukraine), JSC "Nizhniy Tagil Iron and Steel Works" (Russia) and Vyksa Steel Works (Russia).

Technique of hot multiple-stage die forging of wheel blanks is one of the major factors affecting the costs of railway wheel production. In this conjunction, the measures related to optimization of wheel blank forming process scheme, i.e. the measures ensuring productivity increase, reduction of defective products amount, improvement of wheel mechanical characteristics etc., are carried out at the specified enterprises during the last years.

Results and Discussion

"INTERPIPE NTZ" and Vyksa Steel Works initially utilized wheel blank high-temperature forming scheme as follows: preliminary upsetting of cylindrical blank in smooth slabs on press 20 MN, blank upsetting in a floating setting ring, the subsequent centering of blank in a ring and its spread by stamping punch on press 50 MN, finishing forming in closed press tool on press 100 MN (**Figure 1a**). Finished blank quality is eventually defined by setting ring diameter and value of blank spread on press 50 MN [1, 2] in case of this deformation scheme. In addition, specified parameters could be provided in the process of wheel manufacture from blanks having mass deviation in a wide range (up to 40 kg).

In this case, surplus metal, which presence is determined by method of primary blank manufacture and its separation into blanks, is extruded in the upper part of a press. Further surplus metal is extruded in a wheel tread with the subsequent increase of its outside diameter. Wheel diameter can be changed by turning on turning mills if necessary. Lack of metal in the blank is extremely undesirable under this deformation scheme, as it can cause manufacture of wheels with undersized diameter or make this wheel defective.

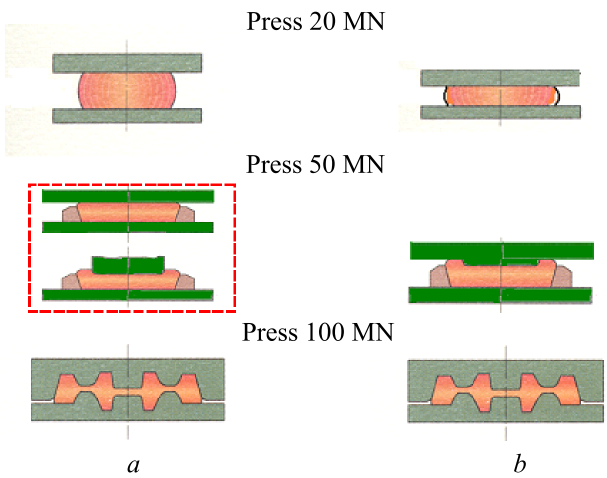
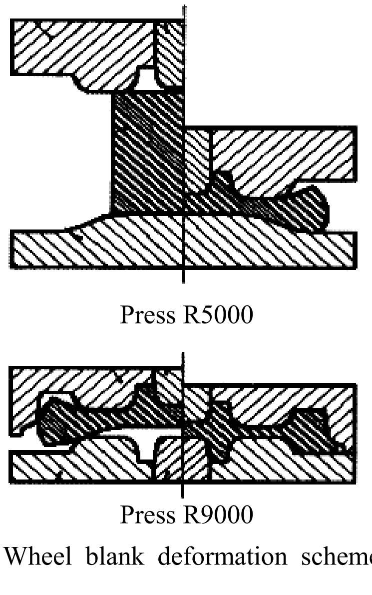


Figure 1. Scheme of wheel blank deformation at Vyksa Steel Works: *a* – initial scheme; *b* – scheme with combination of upsetting and spread

However, the possibility of using blanks with great balance weights in wheel production leads to an increase in wheel machining costs and has a negative effect on level of metal consumption. In this conjunction, the measures (boring of steel moulds for fixed diameter and application of cold cut saws for ingot cutting) performed at Vyksa Steel Works ensured decrease of balance weight up to 9.5 kg in 97% of ingots. In turn, this stabilization of wheel blanks in relation to weight allowed more rational scheme of their deformation providing combination of upsetting and spread on press 50 MN and ensuring increase of productivity (**Figure 1b**) [3].

Use of given scheme of wheel blank working provides centering of wheels on press 50 MN. At Vyksa Steel Works, this problem was solved by preliminary blank upsetting on 20 MN press and subsequent centering of worked blank in a setting ring of press 50 MN through its side face. Disalignment of vertical axes of blank and upper forming slab reaches 4 mm at this centering [3]. This obstacle does not allow complete elimination of such defects formation as eccentricity and variation in wall thickness of wheel hub.

Use of primary blanks with balance weight up to 3 kg allowed JSC "Nizhniy Tagil Iron and Steel Works" to apply more rational scheme of wheel blank pressing offered by corporation “SMS – Eumuco” (**Figure 2**).



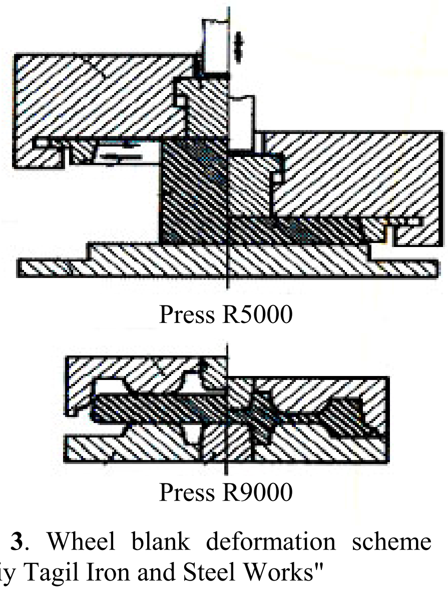
Press R5000

Press R9000

Figure 2. Wheel blank deformation scheme “SMS – Eumuco”

This wheel blank deformation scheme in combination with preliminary scale removal from the whole blank surface allows forming wheel blanks in two passes on presses 50 and 90 MN (in case of JSC "Nizhniy Tagil Iron and Steel Works"). At the same time, upsetting press 20 MN is not used in a processing chain. At the first stage of blank pressing (press R 5000 50 MN), free upsetting with simultaneous spread of metal in the lower blank half, formation of hub and part of disk in the upper wheel half are used. At the second stage (press R 9000 90 MN), additional press forming of upper wheel half and press forming of lower wheel half with accomplishment of wheel flange are conducted. Centering of wheel blanks is performed by centering units.

However, the practice of using this wheel blank pressing scheme revealed its substantial sensitivity to various processes of press forming. In particular, out-of-roundness of primary blank, cutting angle of blank, inaccuracy of blank centering, parallel misalignment of upsetting slabs during blank deforming on press 50 MN led to ovalization and gage interference of worked blank, which subsequently affected the level of defective wheels (up to 25%) because of rim eccentricity in relation to the hub and amount of wheels with undersized diameter (to 12%) [4]. Moreover, blank deformation scheme “SMS – Eumuco” predetermines unhomogeneity of deformation lengthwise the wheel hub, which affects strength and hardness level of its metal [5]. In turn, non-uniform distribution of hardness lengthwise hub has a negative effect on dimensional accuracy of hole during reboring (the difference of diameters should not exceed 50 microns). High level of reject at JSC "Nizhniy Tagil Iron and Steel Works" resulted in using simplified scheme of press forming (**Figure 3**).



Press R5000

Press R9000

Figure 3. Wheel blank deformation scheme at JSC "Nizhniy Tagil Iron and Steel Works"

At this press forming scheme, in the first pass the blank is upset on press 50 MN between smooth slabs in a floating ring. In the second pass, full-face wheel blank is obtained on press 90 MN for the subsequent finishing of tread and part of wheel disk on a wheel rolling mill. Thus, press forming of blanks on press 90 MN without defects is determined by worked blank geometric parameters. For example, to obtain a well structured hub and joining part of disk with hot sizes 23-26 mm for a wheel ø 957 mm on press 90 MN in accordance with GOST 10791-2004, worked blank should be as high as 105-110 mm. At the same time, to obtain a good wheel tread on a wheel rolling mill, its width (i.e. worked blank height) should be within 172-175 mm in the primary blank. In this case, insufficient filling of upper die cavity of press 90 MN is inevitable [6].

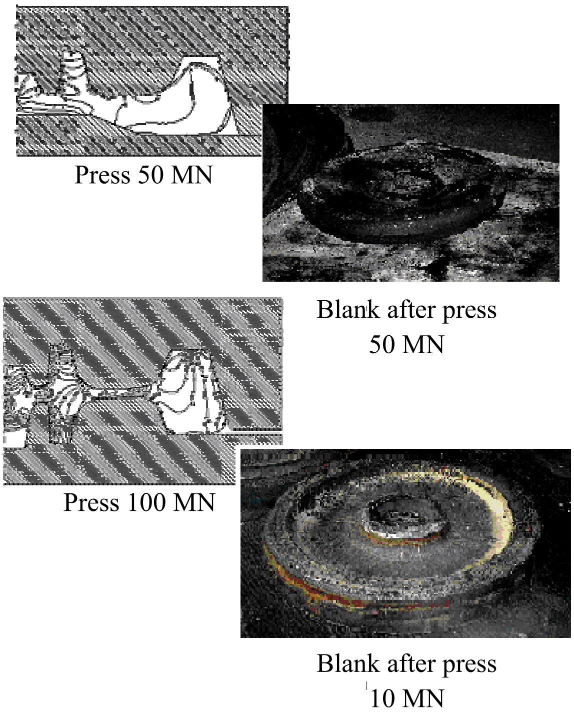


Figure 4. Experimental scheme of wheel blank deformation at JSC "INTERPIPE NTZ"

Results of investigations performed by scientists of National Metallurgical Academy of Ukraine in common with experts of JSC "INTERPIPE NTZ" showed that in the process of full-face blank press forming from worked blank, the force of press forming increased by 15% on the most heavy-loaded press (90 MN) as compared to press forming of full-face wheel blank from preliminary shaped blank, which essentially affects maintenance costs. And parameters of degree and rate of deformation are redistributed for the worse, which taking into account effect of interdeformation pauses and degree of accumulated deformation leads to increase of metal grain size in hard deformable central zone of wheel tread and lowers its viscous properties [7].

Experts of JSC "INTERPIPE NTZ" in collaboration with scientists of National Metallurgical Academy of Ukraine have developed and tested the method of wheel manufacture with the use of wheel blank press forming scheme presented in **Figure 4** [8].

Suggested scheme provides press forming of wheel blanks in two passes with the use of two presses 50 and 100 MN. It is similar to scheme "SMS – Eumuco", except for: blank profiling on press 50 MN is carried out in a gauge ring; the blank is given a half turn prior to die pressing (100 MN).

Use of gauge ring allows reducing ovalization and uneven gauge of blank that occur during its forming on press 50 MN. Blank turning promotes better formation of its tread and reduces unhomogeneity of deformation lengthwise the hub as compared to scheme presented in **Figure 2**. In this case, balance weight of primary blanks is considered when determining sizes of press-tool die 50 MN.

Conclusions

Performed analysis allows recommending the blank press forming scheme presented in **Figure 4** as more rational in comparison with the others. This scheme ensures increased mechanical properties of metal in the central zone of wheel tread and metal of wheel hub. The specified scheme allows press forming of full-face wheel blanks on two presses with lower loadings on the second press. It has a positive effect on productivity and operation costs (maintenance and equipment repair, etc.), especially when manufacturing locomotive wheels with diameter up to 1200 mm.

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Выбор технологической схемы многопереходной штамповки заготовок железнодорожных колес

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В статье представлена более рациональная схема штамповки заготовки колес, которая обеспечивает повышенные механические характеристики металла центральной зоны обода и металла ступицы колеса.