STUDY OF THE FORGING PROCESS IN A NEW DESIGN TOOL IMPLEMENTING ALTERNATING DEFORMATIONS

Sergey Lezhnev[1], Abdrakhman Naizabekov[1], Dmitry Kuis[2], Evgeniy Panin[3]

[1] *Rudny Industrial Institute, 38 50 let Oktyabrya str. Rudny 111500, Kazakhstan*
[2] *Belarusian State Technological University 13a Sverdlova str., Minsk, 220006, Belarus*
[3] *Karaganda Industrial University 30 Republic Ave., Temirtau, 101400, Kazakhstan*
E-mail: sergey_legnev@mail.ru

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ABSTRACT

The influence of the forging process of round cross-section blanks in a new designed forging tool implementing alternating deformations on the microstructure and mechanical properties of DIN 1.2542 steel was studied. The research results show that forging blanks using the proposed technology in a new forging tool, compared with the current forging technology in flat strikers, allows obtaining higher quality metal with an equiaxed fine-grained structure.

Keywords: alternating deformation, forging, microstructure, mechanical properties.

INTRODUCTION

Forging technologies and equipment for their implementation, currently used in forging and pressing production, have often been outdated for a long time and require improvement and modernization. In most cases, they are ineffective and do not provide workpieces of the required quality, or they do, but have significant energy and labor costs. For example, broaching, as one of the main forging operations, is often implemented still in flat strikers and proceeds not only under conditions of uneven metal flow in height but also under significant tensile stresses owing to the presence of friction forces on the contact surface. All this significantly reduces the quality of the obtained workpieces.

Therefore, the main direction of forging processes improving is to achieve the stress and strain state uniformity. This effect ensures the implementation of shear or alternating deformation in the deformed metal volume. It can be achieved by improving the configuration of the forging tool [1 - 12].

The purpose of this study is to investigate the influence of the forging process in a new designed forging tool that implementing alternating deformations in the entire volume of a circular cross-section deformable billet on the structure and mechanical properties of DIN 1.2542 steel.

EXPERIMENTAL

A laboratory experiment on workpiece deformation in a new design forging tool using a hydraulic press PB 6330-02 with a force of 1000 kN was carried out. In order to conduct a laboratory experiment to study the effect of the new forging technology in a new design forging tool on the microstructure evolution and changes in mechanical properties, billets of DIN 1.2542 economically alloyed steel with a diameter of 40 mm and a length of 250 mm were prepared. To restore the initial structure, the workpieces were annealed at 700°C for 40 min in a chamber resistance furnace before deformation [13].

The workpieces were heated to a temperature of 1000°C (in accordance with the previously obtained computer modeling results), fed into a new design forging tool and deformed according to the scheme shown in Fig. 1 [14].

In order to approximate the cross-sectional shape of the deformed workpiece to a round one, the workpiece compression series in this forging tool with its turning by 45°, and then by 30° were carried out. As a result, blanks with a cross-sectional shape close to a circle with a diameter of 30.0 mm were obtained. For comparative analysis, the second batch of blanks was subjected to broaching in flat strikers up to a diameter of 30.4 mm.

For microstructure study the templets on the BRILLANT 230 ATM wet abrasive cutting machine were cut, and microsections on the SAPFIR 520 polishing and grinding machine were prepared. Microsections from the original undeformed (after annealing) blanks were also prepared. The prepared microsections were etched in the following reagent: 10 ml of a 4 % alcoholic solution of picric acid, 10 ml of a 5 % alcoholic solution of nitric acid [15].

RESULTS AND DISCUSSION

Microstructural analysis was carried out on JSM-5610 LV scanning electron microscope. It showed that the microstructure of undeformed DIN 1.2542 steel represents a uniform distribution of perlite and ferrite in the ratio of 63 % and 37 %, respectively (Fig. 2(a)).

Ferrite grains have approximately equiaxed shape and smooth borders. Perlite is a dark-etching formation with an indistinctly pronounced lamellar structure. The pre-annealing due to the complete recrystallization of the metal made it possible to obtain an equiaxial structure. Due to annealing, there was a complete removal of internal stresses and this metal has good ductility and viscosity, which is so necessary for subsequent forging.

The results of the microstructure study after deformation according to the proposed and current technologies are shown in Table 1.

After forging by both technologies, the resulting microstructure retained its ferrite-pearlite state, but its fragmentation into smaller grains with a large number of dislocations distributed mainly along grain boundaries occurred.

The microstructure analysis showed that forging according to the current technology in flat strikers leads to a slight grinding of grain, an uneven structure distribution in various directions is observed, and elongation in the longitudinal direction is also manifested. The microstructure is characterized by the presence of both recrystallized and deformed grains (Fig. 2(b)). The average grain size was 35 microns.

After forging according to the proposed technology in a new forging tool implementing alternating deformation, the resulting structure is more homogeneous, but the carbide phases are distributed unevenly along the grain boundaries. The structure of pearlite colonies has

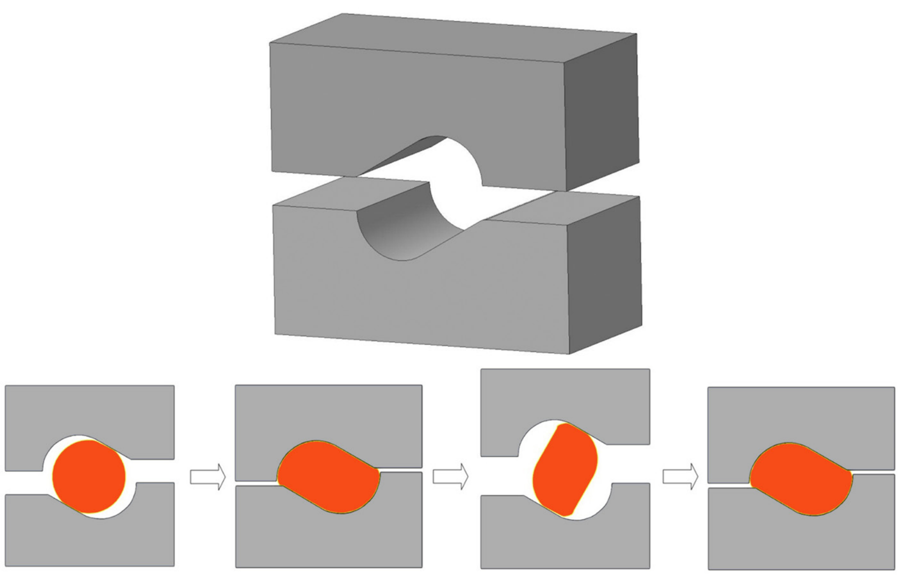

Fig. 1. Tool construction and broaching scheme in a new design forging tool.

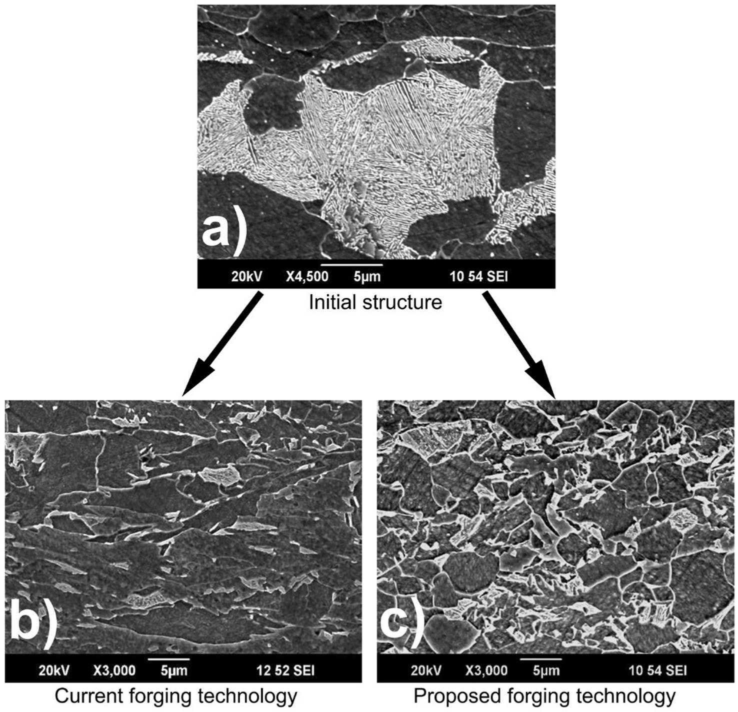

Fig. 2. Microstructure of DIN 1.2542 steel.

Table 1. Results of determination the average grain size.

Tool	Direction	Initial grain size, µm	Average grain size after deformation, µm
new design forging tool	transverse	42	17
	longitudinal		18
flat strikers	transverse		32
	longitudinal		38

undergone significant changes, cementite plates have different thicknesses, are distorted and curved, and in some cases are divided into separate parts. The average grain size of ferrite and perlite was 18 microns (Fig. 2(c)).

As it is known, the change in the metal microstructure has a significant effect on the mechanical properties. Therefore, at the second research stage, the influence of the forging process in a new design tool on the mechanical properties of DIN 1.2542 steel was studied. For this purpose, standard tensile samples were made from blanks formed according to the proposed and current technologies, as well as from the original templates. Tensile tests were carried out on Shimadzu AG 100kNx electromechanical testing machine. To exclude systematic errors during the tests, they 3 times were duplicated. The averaged values of mechanical properties before and after deformation by two technologies are presented in Table 2.

Analysis of the mechanical properties results showed that the strength properties during forging by both technologies increased. However, the yield strength and tensile strength of DIN 1.2542 steel forged according to the proposed technology is 6.5 % higher than that of samples forged according to the current technology. Elongation, as a plastic characteristic, after deformation in the strikers of both types, on the contrary, decreased. But at the same time, the elongation value when using the proposed technology is on average 10 % higher than that of samples formed according to the current technology in flat strikers.

Table 2. Mechanical properties of DIN 1.2542 steel.

Tool	Property	Average values of properties	
		Initial	After deformation
new design forging tool	yield strength, MPa	834	1052
	tensile strength, MPa	912	1185
	elongation, %	15.1	12.3
flat strikers	yield strength, MPa	834	985
	tensile strength, MPa	912	1107
	elongation, %	15.1	11.2

CONCLUSIONS

The change of microstructure and mechanical properties of DIN 1.2542 steel during forging process in a new designed forging tool implementing alternating deformations on the microstructure and mechanical properties was studied. The expediency of using the proposed forging technology and strikers for its implementation, instead of the currently used forging technology in flat strikers, has been proved, since the proposed forging technology with a similar forging as when forging in flat strikers, allows to obtain blanks of higher quality with a uniformly distributed equiaxially fine-grained structure. Obtained results have shown that new design of strikers allows to increase the metal processing level, which led to higher grain grinding. At the same time, the level of strength parameters after deformation in new strikers is higher for 25 - 30 %, when this value was 18 - 20 % for flat strikers.

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