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The influence of asymmetry of tools on the removal of metallurgical defects and discontinuity in 18G2A steel forgings

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The article discusses the effect of the main forging parameters and the selection of tools on improving the closing up discontinuities of metallurgical origin during forging.
A laboratory analysis of the forging process was performed. Results obtained from the process were processed using a graphical program.

The effect of shape of tools on closing up material defects of metallurgical origin was investigated. As a result of investigations, the optimal values of the main technological parameters of forging have been determined, and the application of an appropriate group of tools have been proposed for the flat die forging of forgings.

1. INTRODUCTION

Studies on the uniforming of forging reduction ratios in the cross-section of forgings are reported in several works [1÷4]. They indicate that the uniforming of forging reduction ratios in forgings is influenced significantly by the main forging process parameters, such as draft, feed, stock temperature, and the shape and dimensions of flat dies. These studies aimed at the optimization of forging process parameters and the shape of flat dies in order to obtain forgings free from internal defects.

The present article reports the results of studies on the determination of the shape and geometry of tools with an aim to obtain a closure of defects of metallurgical origin in forgings during flat die forging.

2. MATERIALS USED IN TESTS AND THE BOUNDARY CONDITIONS OF THE FORGING PROCESS

Laboratory tests were performed for specimens with a diameter and a height of 80 mm made of 18G2A construction steel designed for hot operation.

The tests of model ingots with the aforementioned dimensions were carried out in asymmetrical non-axis dies Fig. 1 and asymmetrical three radial dies Fig. 2, as well as in flat dies.

Table 1
Chemical composition construction steel 18G2A according PN-86/H-84018

Chemical composition	C	Mn	Si	P	S	Cr	Ni	Cu
Steel grade 18G2A, %	0,2	1,5	0,55	0,04	0,04	0,3	0,3	0,3

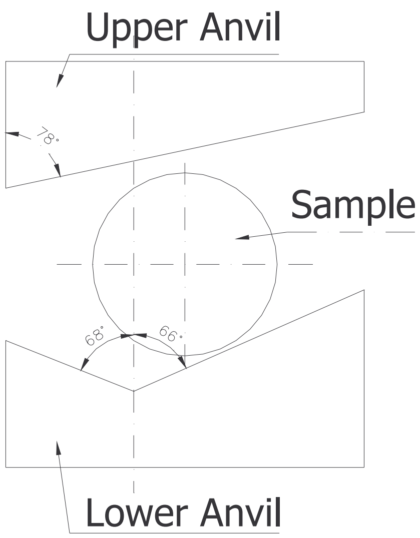

Figure1. Asymmetrical non-axis dies

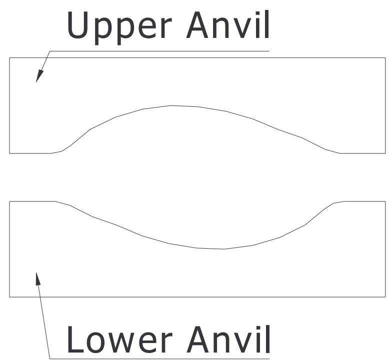

Figure 2. Asymmetrical three radial dies

Preforging with the draft ε=15% took place in shaped dies. After the first upsetting, the forging was tilted by 90°. Finishing forging was done on flat dies. Draft during forging on these dies was ε=30%. The velocity of the upper die was 12 mm/s. The initial temperature of the stock was constant within the whole volume and was 1150°C. The temperature of anvils was 350°C, while the ambient temperature being 20°C. The specimens were deformed on a 10MN hydraulic press.

3. EFFECT OF THE TOOL SHAPE AND TECHNOLOGY ON CLOSING UP DISCONTINUITIES

The effect of the shape of tools on closing up discontinuities was tested on cylindrical specimens in which 8 and 10 mm-diameter holes were made, which were to simulate real defects of metallurgical origin. The arrangement of holes and the dimensions of specimens are shown in Fig. 3.

Specimens were deformed on a hydraulic press with a pressure of 2500 kN. The boundary conditions of the forging process, as well as the combination of tools used for deformation were selected in the same manner as for the analysis of forging reduction ratio distribution.

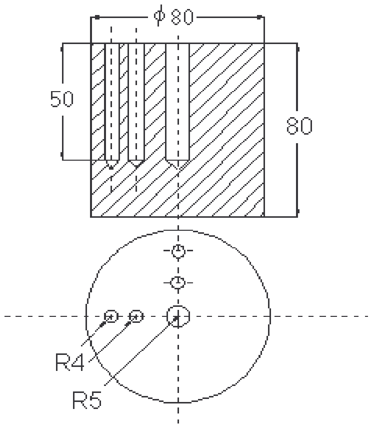

Figure 3. A specimen for testing metallurgical-origin defects in the material.

After deformation, the specimens were cut at one-third and at half of their length, and then microsections were made on the cutting surfaces to determine accurately residual defects and their size.

Example photographs of microsections are shown in Fig. 4 and Fig. 5 below.

a) b)

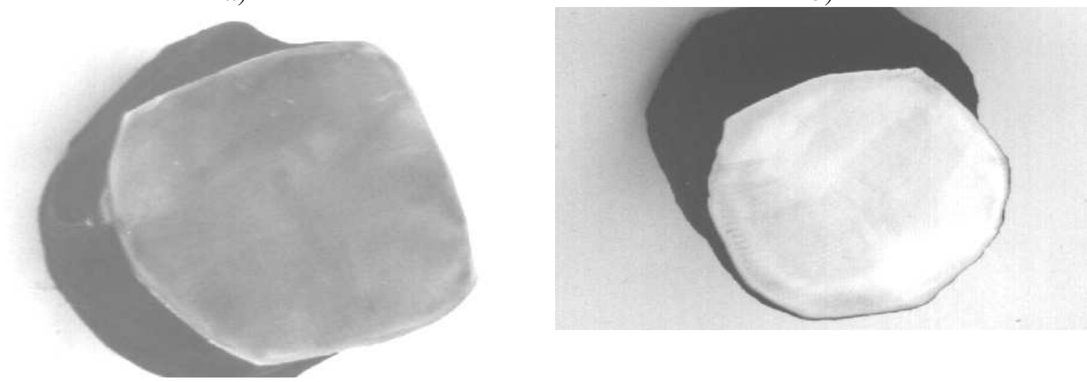

Figure 4 View of a microsection preforged on triradial dies and then on flat dies. a) cut at a distance of 1/3 of the forging length; b) cut at a distance of 1/2 of the forging length

a) b)

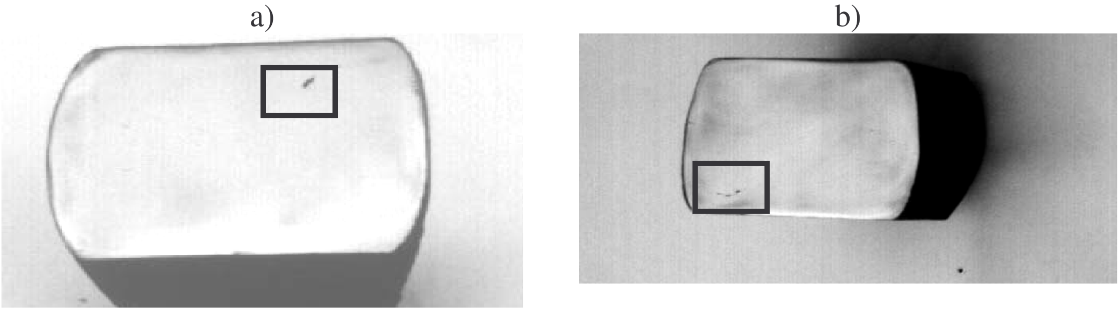

Figure 5. View of a microsection preforged and finishing forged on flat dies. a) cut at a distance of 1/3 of the forging length; b) cut at a distance of 1/2 of the forging length. Places with unclosed discontinuities are shown in boxes

It was found on the basis of the tests that the best effect in closing up artificially made defects was obtained during forging on shaped dies, and forging on flat dies turned out to be completely undesirable. The test results confirmed the conclusions from theoretical analyses [5] which recommended the use of shaped dies in the initial forging process. These, in fact, do not cause a rapid forging through to the inside of the material and a large widening towards the planes unlimited by the dies surface.

After preforging with shaped dies the material is forged out on the peripheries and does not flow so freely as during forging with flat dies. As a result, on flat dies used as finishing dies material is forged through, thereby closing up any defects on the material borders, which have not been lost Fig. 4.

The use of flat dies for preforging prevents the holes from flattening under the effect of material flow and allows them to pass unclosed towards the planes not limited by the anvil surface in flat die forging Fig. 5.

Artificially made defects, after being deformed on shaped dies and then on flat dies, closed up completely. Defect deformed exclusively on flat dies, on the other hand, were curvilinear in character, and were shifted to the forging borders as a result of the undesirable kinematics of material flow, which is induced by flat dies.

4. CONCLUSIONS

It can be stated based on the laboratory tests that the use of shaped dies in preforging operations has a desirable effect in terms of the uniformity of material forging out within its whole volume, as well as in terms of the removal of metallurgically originated defects. This is important in view of the fact that flat die forging processes have been performed so far in forging shops using flat dies only.

It is seen from the results of studies described in this article that with the shape of the tool and the appropriate forging process parameters we can significantly control the kinematics of material flow during the process of forming a forging.

The positive and promising results of analyses encourage us to continue studies in this field.

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