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Precision analysis in billet preparation for micro bulk metal forming

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Abstract
The purpose of this research is to fabricate billets for an automated transfer press for micro forming. High performance transfer presses are well-known in conventional metal forming and distinguished from their automation and mass production. The press used in this research is a vertical mechanical press. When using a vertical mechanical press, the material is fed as billets into the forming zone. Therefore, a large number of highly uniform billets are required to run mass production in such a setup. Shearing technique was used for manufacturing the billets. The efficiency of the shearing tool is examined in terms of volume control, circularity, dimension and sheared surface quality. The shearing tool is based on holders for both bar and cutoff. The tool is fixed in dimensions, since the dimensions of billets are fixed throughout experiments of this research. The paper presents the experimental analysis of the precision of the billets prepared by the tool.

Keywords: micro forming, billet, shearing, mass production, precision

1. Introduction

Metal forming is often used for manufacturing of parts in high volume production. This need is primarily met by automated transfer presses. When manufacturing micro metallic parts by micro forming, the same concept of traditional high performance transfer presses can be utilized for mass production. For micro bulk forming, the raw material originally comes from drawn wire where they are supplied in the form of coils. Depending on the structural design, there are vertical or horizontal transfer presses.

In vertical mechanical presses the billets are fed individually. Consequently, the original stock must already be sectioned into necessary sizes. Since mass production is required for economic forging production, shearing is the main manufacturing process for billet production from coil. When performing shearing operation, there is no loss in material and billets are produced in high output rate while the edge of material is deformed and hardened slightly.

In 2005, Altan showed a survey of the methods for billet manufacturing in cold and hot forging in a book under the chapter "Billet separation and shearing" [1]. In 1998, Schuler GmbH, published a document demonstrating four principles of shearing for billet production [2].

Previous study indicated a new developed high performance transfer press in micro forming [3]. The machine tool is a vertical mechanical press. This paper introduces a simple tool for this purpose. The analysis includes measurements for the weight, height, surface quality and roundness of cropped specimens.

2. Experimental setup

When manufacturing the billets, it is important to maintain tight tolerances on all dimensions in order to control the volume and weight of billets; otherwise the final forged part will vary, introducing errors in geometry of the workpiece. To reduce this variability, a tolerance of less than 1% is resquested for the weight and the length of all billets

The schematic structure of the shearing process is shown in Figure 1. The four principles of shearing are: with bar and cutoff holder, with bar holder, without bar and cutoff holder, utilizing axial pressure.

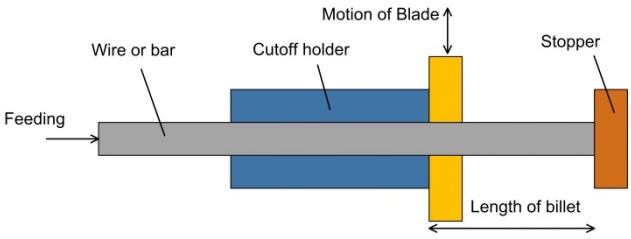

Figure 1. Schematic of shearing mechanism

The performance of the developed transfer press was examined in one case with a two-stage forging [4]. The billets used in the process had 5 mm length and 2.0 mm diameter. The cropping tool is fixed in dimensions. The material is Al99.5 coming from a coil. The wire has a nominal diameter of 2 mm. For this research, the shearing tool is based on holders for both bar and cutoff with no axial pressure. The experimental setup is shown in Figure 2.

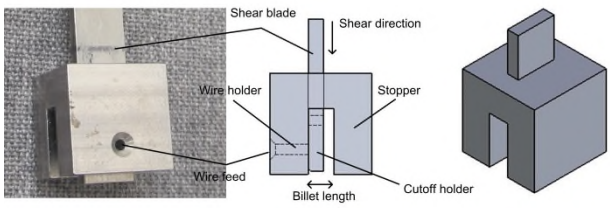

Figure 2. Cropping tool

In order to more exactly determine the precision of the produced billets, a volume production of 1250 billets was employed by means of the prototype shearing device. The production was performed in 25 consecutive groups of 50

billets each. To verify the repeatability of the result, one specimen randomly was selected from each group for measurements. Therefore, 25 repetitions of measurements were conducted.

3. Weight and length error

The curves of variation and frequency for 25 representative sheared billets while measuring the weight and length are shown in Figures 3 and 4 respectively. When comparing the weight measurements of the specimens, the average of 41.66 mg and a standard deviation of 0.144 mg is observed. When applying ±2 standard deviations (0.29 mg), 0.5% volume deviation and notable accuracy in sheared billets due to cropping can be seen from Figure 3. Likewise, when measuring the length of selected specimens, an average of 5.047 mm and standard deviation of 3µm is observed (Figure 4). When applying ±2 standard deviations (6 µm), the result validates that the slug shearing process is capable of producing high quality billets in micro bulk forming and thus it is suitable for application in volume production.

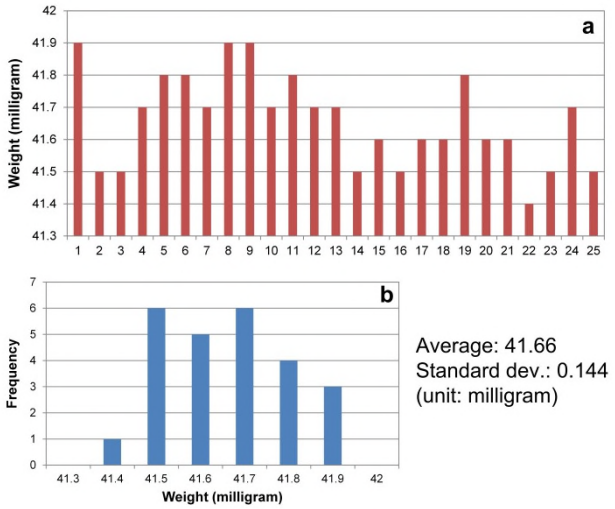

Figure 3. Weight error of produced billets; (a): variations of weight of 25 representative produced billets of 1250; (b): weight-frequency analysis of 25 cropped billets

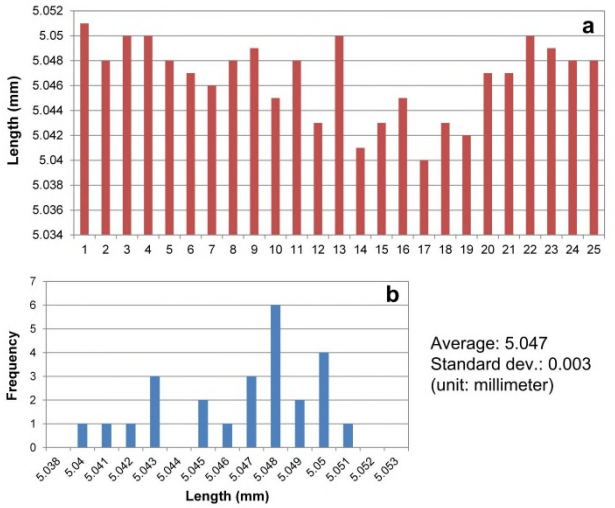

Figure 4. Length error of sheared billets; a:variations of length of 25 representative produced billets of 1250;b: weight-frequency analysis of 25 cropped billets

3.2. Sheared surface

To observe the sheared surface of cut specimens, a rack was made by 3D printing with 25 places for billets. The billets were mounted and arranged in the rack. From the visual inspection of the tested specimens, it can be noted that the testing region of most slugs displayed a fracture zone. Also of note is that the fractured area grows slightly among the billets when increasing the number of produced billets (Figure 5). To provide more detailed analysis of ovality on specimens, the cross section of the specimens in the batch 1 and 25 are examined in Figure 6. As can be seen, the base circle plot shows a radius of about 968 µm for a billet from batch 1 while the base circle of oval section reveals the radius of 880 µm in batch 25. This may occur due to increasing shearing tool clearance or decrease of the sharpness of the blades.

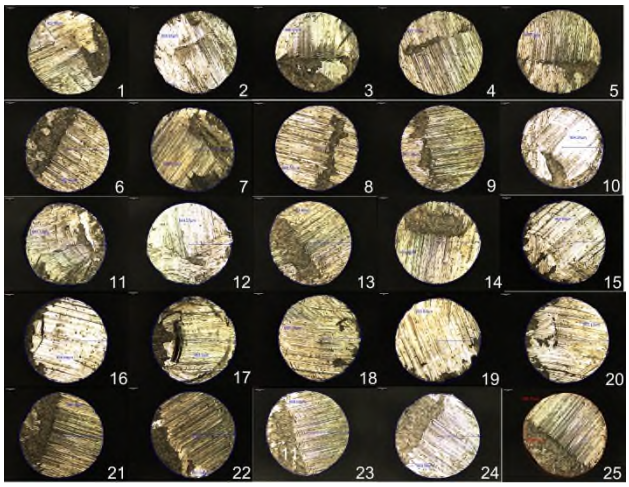

Figure 5. Comparison of sheared surfaces of produced billets

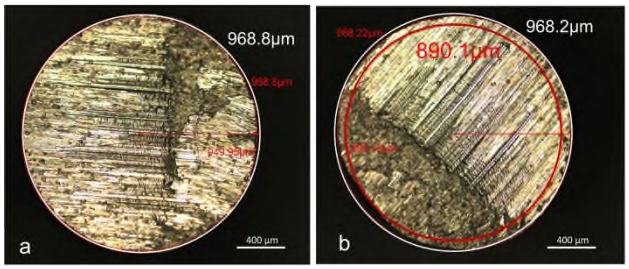

Figure 6. Roundness of sheared billets; a: batch 1; b: batch 25

4. Conclusion

This paper introduces a simple cropping tool for volume production of billets. The clearance of 3% is applied to the device for shearing process. 1250 billets are fabricated for precision analysis by the cropping tool. The analysis shows a total average weight of 42.4 milligram with an error of ±0.29 mg when applying ±2 standard deviation corresponding to 0.5% volume deviation. Variance of ±6 µm is found in length with an average of 5.047 mm. The ovality is analysed using a comparison of sheared surfaces for batch 1 and 25 where a considerably larger error occurred. Increasing the time decreases the accuracy of the circularity to a great extent, when having no significant effect on the length and volume.

References

[1] Altan, T., Ngaile, G., & Shen, G. 2005 **1**. Materials Park (OH): ASM international.
[2] Schuler GmbH, 1998, Springer.
[3] Mahshid R, Hansen HN, Hansen C, Arentoft M 2013 *ASME 2013 Manufacturing Science and Engineering Conference (MSEC)* Wisconsin University.
[4] Mahshid R, Hansen H N, Arentoft M 2014. *Procedia Engineering* **81** 1445-1450.