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## Study on the Influence of Die structure on Ultrafine Grain Materials

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# Study on the Influence of Die structure on Ultrafine Grain Materials

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**Abstract.** Ultrafine crystal materials have excellent mechanical properties and mechanical properties, the preparation of ultrafine crystal materials has been highly valued in actual production and life. Severe plastic Deformation (SPD) method is a newly developed method for the preparation of superfine crystal materials. Groove pressing (GP) method is a kind of SPD method. Compared with other methods, this method with the production process is simple, easy to operate and mass in industrial production. In this paper, through a combination of practical experiments and numerical simulation to analyse tissue samples at different mold structure deformation evolution, the cumulative amount equivalent strain, strain degree equivalent uniformly distributed load changes, as well as fine tissue after deformation of the situation, to explore the structure of the mold plate deformation of molded pure nickel. It used to guide the production and preparation of ultrafine grained plate, as well as industrialization and mass production of ultra-fine grain plate explore the law.

## 1. Introduction

With the rapid development of manufacturing in the society, people have higher and higher requirements for mechanical properties and mechanical properties of materials. Ultrafine crystals (grain sizes between 100 and 1000 nm) can greatly improve the mechanical and mechanical properties of materials, which has aroused great interest. Many scholars and researchers have invested a lot of energy to study how to better. Preparation of ultrafine grained materials. The severe plastic deformation method is a newly discovered method for preparing ultrafine crystal plates in recent years. In theory, SPD can prepare a large number of ultrafine crystal plates under relatively convenient conditions. However, this method still needs further research and discussion on the mechanism of action and forming theory. How to produce ultrafine-grained materials in large quantities and high efficiency in production and life is also an urgent problem to be solved.

The SPD technology has an extremely high advantage in the preparation of ultrafine crystals, and the compression deformation method (GP) is one of the SPD techniques. Since the SPD technology was proposed, scholars at home and abroad have conducted a lot of research. Although foreign scholars have made some progress in research, there are still many problems in the CGP method that require further research. These problems are mainly concentrated in the GP. Process mechanism, changes in microstructure and properties during deformation of the sample, conditions during deformation, and effects of mold structure on the process. There is still little research on the influence of the mold structure,



especially the inclination angle of the mold on the GP process of the sample, and there is no systematic, unified theory.

In this paper, the actual experiment and the finite element software simulation method are combined to further explore the variation of the equivalent strain accumulation, the microhardness, the metallographic structure and the upper mold load of the mold structure during the deformation process of the GP process. Discuss the influence of mold structure on the mechanism of GP process. Master the process principle of molding deformation, establish a pure nickel sheet molding deformation process experiment system, and establish a corresponding finite element simulation model based on the numerical simulation software Deform. Combined with numerical simulation and process experiments, the influence of mold structure on the microstructure and mechanical properties of pure nickel sheet during compression deformation and the uniformity of deformation were studied.

## 2. Experimental study on the influence of die structure on industrial pure nickel GP process

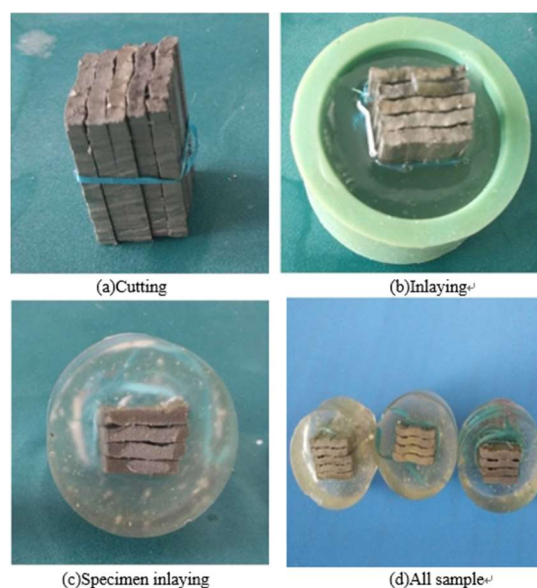
This part mainly introduces the experimental materials and testing methods.

This experiment chooses industrial pure nickel (N6,99.5%) as experimental material, and the composition of industrial pure nickel (N6,99.5%) is shown in Table 1, consults relevant literature and refers to heat treatment manual.

**Table 1.** Industrial pure nickel chemical composition (mass fraction /%).

Ni	Gu	Si	Mn	C	Mg	S	P
≥99.5	≤0.06	≤0.1	≤0.05	≤0.1	≤0.1	≤0.005	≤0.002
Fe	Pb	Bi	As	Sb	Zn	Cd	Sn
≤0.1	≤0.002	≤0.002	≤0.002	≤0.002	≤0.007	≤0.002	≤0.002

According to the principle of GP process, firstly, pure nickel sheet is cut into 100 mm x 66 mm x 2 mm by wire cutting, and annealed at 500 C for 4 hours and cooled in furnace. Secondly, after the deformation of pure nickel sheet, small specimens of 20 mm (X direction) \*20 mm (Z direction) are intercepted on each large sheet and embedded together, as shown in Figure 1(a). In order to facilitate the following operations, the samples with different passes pressed by the same mold structure were cold-embedded together. The original samples were put together with those pressed by plan iii mold as shown in FIG. 1(b) and 1(c), a total of three pieces were cold-embedded, as shown in FIG.1(d).



**Figure 1.** Metallographic specimen preparation.

Finally, grinding with sandpaper, the sample surface was treated and the metallographic structure was observed by XDS-330D optical microscope. The regularity was found out. The photograph was taken by IE200M inverted metallographic microscope with a ruler.

### 3. Effect of die structure on microstructure of specimen

#### 3.1. *Effect of die tooth width on microstructure of specimen*

The refinement of the specimen mainly occurs in the first deformation pass, and the grain size decreases gradually in the subsequent deformation pass, but the refinement effect is smaller than that of the first deformation pass. The effect of small die tooth width on grain refinement is more obvious, especially in the first deformation, the grain refinement rate of small die tooth width is 24.8%, and that of large die size is 0.3%, which is greater than that of subsequent deformation passes. From the overall trend of the curve, the smaller die tooth width fines the sample better than the larger die tooth width in the process of deformation. The width of the mold tooth width from the die tooth width is better than that of the sample.

#### 3.2. *Effect of die dip angle on microstructure of specimen*

Different die structures have great differences in grain refinement. Small die tooth width and large die inclination angle have the best effect on sample refinement. The degree of grain refinement has little to do with the number of deformation passes. There is a suitable combination of die inclination and die size to optimize the sample.

### 4. Conclusion

The influence of the mold structure on the pure nickel sheet GP process is mainly reflected in the influence of the mold inclination angle and the mold tooth width on the GP process, wherein the mold inclination angle has a greater influence than the mold tooth width. The deformed area of the sample is most obvious during the deformation process. The maximum value of the equivalent strain occurs in the shear deformation zone. During the single pass deformation, the sample is pressed1 to flat1 to press2 and then to flat2. The cumulative accumulation gradually becomes larger, and the degree of cumulative uniformity of the equivalent strain gradually becomes better. During the multi-pass deformation process, the equivalent strain accumulation of the sample increases with the increase of the deformation pass, but the degree of homogenization of the equivalent strain accumulation will deteriorate with the increase of the deformation pass, which is related to Yoon echoes the predictions made by the "relative strength theory."

In the pure nickel plate GP process, compared with the small die width, the large die width increases the rate of equivalent strain during the deformation of the sample, and the cumulative strain of the sample is far away. Less than the mold tooth width. During the multi-pass deformation process of the sample, the homogenization of the large mold tooth width to the equivalent strain accumulation of the sample is better than the tooth width. The large mold inclination angle increases the cumulative strain of the specimen with the increase of the deformation pass, and the accumulation rate is also large, but the small mold inclination angle is easier to maintain the uniformity of the equivalent strain accumulation of the better sample.

From the sample hardness value, TEM photo, SEAD pattern photo, the mold structure of Scheme 2 is the best for the refinement efficiency of the sample. From this we can see that the mold structure has a very significant effect on the pure nickel plate GP process, but It is not that the inclination of the mold or the width of the mold tooth tends to be as high as possible. There is an optimum matching value between the inclination angle and the tooth width. The matching value can be obtained by ensuring that the sample does not break after a suitable deformation pass. Ultra-fine grain pure nickel sheet with good mechanical and mechanical properties.

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