DEVELOPMENT OF SIMPLE BIAXIAL-TENSILE-TESTING APPARATUS USING LATHE CHUCK

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INTRODUCTION
As the automotive industry addresses environmental concerns, the problem of fuel efficiency and weight reduction has come to the fore. Reducing the weight of automobiles is one of the primary concern by which their fuel efficiency is lowered. The two basic approaches are in automotive design and in materials selection, and they are closely related. Regarding materials, there has been a trend toward the use of not only light metals and also their alloys like as aluminum, magnesium and titanium but also ultra high strength steel in automotive components, particularly automotive bodies. However, such materials in press forming tend to produce fracture, surface deflection, spring back and so on. For this reason, a try and error increases and it has become a cause of a trial production period and cost escalation. The elucidation of the fracture of those materials and the prediction of the forming limit are important technical issues in the field of plastic processing.

The biaxial tensile testing apparatus of the hydraulic control for which the estimation method of material used cruciform specimen is already developed [1]. This apparatus has measured the forming limit and yield loci of various materials with sufficient accuracy. However, in order to pursue performance, apparatus is large-sized and is complicated. Development of a simple and accurate evaluation technique is desired in Small and Medium Enterprise or a manufacturing site. Using the scroll chuck used for a lathe, we developed the apparatus in which tensile with two simple axes is possible and to test. Then, independent chuck by which each axis is independent and operates, arbitrary stress ratio condition are made to act on a specimen, and this study aims at measuring the plastic deformation characteristic with high precision of the apparatus and strain ratio after fraction of sheet metal.

DESIGN OF SPECIMEN
The test material used in this study is an aluminum A1050-O sheet with a thickness of 1mm. Figure 1 shows the geometry of specimen used in this study. The normal strain components, $\varepsilon_x$ and $\varepsilon_y$, were measured using scribed circle as shown by Figure 2 [2].

![Figure 1](image1.png)

**FIGURE 1** Geometry of (a) uniaxial and (b) biaxial tensile specimens

![Figure 2](image2.png)

**FIGURE 2** Overlapped circle

EXPERIMENTAL PROCEDURE
Figure 3 is shown the experimental setup which consists of three portions. They are Independent chuck, motors, and vice1 - vice4 chucking the specimen. The vices are moved by the motor controlled by the personal computer. The normal tensile speed is 5mm/min.

First, uniaxial specimen shown in the figure 1 was attached to the vice1 and vice3, test was done in consideration of the rolling direction of aluminum. Next, biaxial specimen is attached to the all vices. Each cruciform specimen was subjected to proportional biaxial strains with $\varepsilon_x : \varepsilon_y = 1:1, 2:1, 3:1$ and $3:2$, to determine the forming limit diagram.
RESULTS AND DISCUSSION
Figure 4 shows the specimen before and after deformation. The stress-strain curve is shown in Figure 5. It was shown that experimental equipment has the performance as well as the usual tensile testing machine.

Figure 6 shows the cruciform specimen before and after deformation. The forming limit diagram is shown in Figure 7. Fracture strain is small compared with the value. Two reasons can be considered to this result. First, the scribed circle’s diameter was used by 4mm, then the fracture strain was estimated small since the strain gradient is large near the point of the fracture. Next the hollow was processed on the central part of the cruciform specimen. Thickness of the hollow portion was not uniform strain distribution has occurred.

CONCLUSIONS
The uniaxial and the biaxial tensile test of A1050-O sheet metal were done using the simple biaxial – tensile - testing apparatus which operates independent lathe chuck. S-S curve is obtained as good as the conventional uniaxials tensile testing machine. On the other hand, about biaxial test, it became clear that the shape of a specimen needs to be improved. However, arbitrary stress courses were made to act on a specimen, and it became possible to measure the plastic deformation characteristic with high precision.

REFERENCES