FORMABILITY EVALUATION OF DOUBLE LAYER CIRCULAR TUBE AS A DEVICE WITH ENERGY ABSORPTION CAPACITY

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Abstract. Recently, earthquakes frequently occur in Japan. It is desired to promote seismic isolation technology of building. It has been found that newly designed composite material filled with low rigidity material to high rigidity material has significant energy absorbing capacity. However, it must have higher energy absorption capacity in order to respond to a large scale earthquake. Therefore, we have proposed an energy absorbing device with a double layer circular tube as a cell. In previous work, it has been shown that hysteresis occurs and absorbs the energy by friction that is generated between the outer layer and the inner layer. It is effective when inside shape of inner layer is defined as floral pattern. In this study, we considered to form the inner layer circular tube by forward and backward extrusion and to assemble with the outer layer circular tube at the same time. After forming, it is necessary to generate hysteresis around the entire circumference of the circular tube. Ideally, the inner layer circular tube is tightened to the outer layer circular tube. In this research, it was aimed to know the contact state between the outer layer and the inner layer after forming. Therefore, the influence of the presence or absence of the outer layer circular tube on formability was investigated. As a result, there was a tendency for large elastic strain to remain at the contact portion between the circular tubes when the outer layer circular tube was set. This means that the outer layer circular tube hinders elastic recovery of the inner layer circular tube. Therefore, it was confirmed that the inner layer circular tube was tightened by the outer layer circular tube. The same result was obtained when the inner shape of the inner layer circular tube was a flower pattern.

1 INTRODUCTION

Recently, earthquakes frequently occur in Japan. It is desired to promote seismic isolation technology of building. It has been found that newly designed composite material filled with low rigidity material to high rigidity material has significant energy absorbing capacity[1]. However, it must have higher energy absorption capacity in order to respond to a large scale earthquake. Therefore, we have proposed an energy absorbing device with a double layer circular tube as a cell[2]. In previous work, it has been shown that hysteresis occurs and absorbs the energy by friction that is generated between the outer layer and the inner layer[3]. It is effective when inside shape of inner layer is defined as floral pattern. In this study, we considered to form the inner layer circular tube by forward and backward extrusion and to assemble with the outer layer circular tube at the same time. After forming, it is necessary to generate hysteresis around the entire circumference of the circular tube. Ideally, the inner layer circular tube is tightened to the outer layer circular tube. In this research, it was aimed to know the contact state between the outer layer and the inner layer after forming. Therefore, the influence of the presence or absence of the outer layer circular tube on formability was investigated.

2 ANALAYSIS CONDITIONS

In this study, as a method of forming a double layer circular tube, an outer layer circular tube of carbon steel was placed in a die, a cylindrical blank of aluminum was placed inside the outer layer circular tube, and the inner layer circular tube was formed by cold forging. We thought of we can assemble the inner layer circula tube and the outer layer circular tube at the same time as forming the inner layer. About the model shown in Figure 1, the formability of the double layer circular tube by forward and backward extrusion was investigated. Figure 1 shows the analytical model in the presence and absence of an outer layer circular tube. Figure 2A shows the model in which an outer layer circular tube exists. Figure 2B shows the model without an outer layer circular tube. In addition, a case where the inner surface shape of the inner layer circular tube as shown in Figure 3 is circular and a case where the inner surface shape of the inner layer circular tube is a flower shape as shown in Figure 4 were analyzed, and we studied the case that the punch speed is 10 [mm/s], 30 [mm/s] and 50 [mm/s]. For the circular tube, as shown in Table 1, an outer layer circular tube having an outer diameter of ϕ 28.6 [mm/s] and an inner diameter of ϕ 26.2 [mm/s] and a cylindrical blank (inner layer circular tube) of ϕ 26.2 [mm/s] were used. We used A1100(JIS H 4100) for the inner layer circular tube and STKM11A(JIS G 3445) for the outer layer circular tube. Since it is impossible to punch through to the end, the stroke was set so that the wall thickness of 2 [mm] remains after forming.

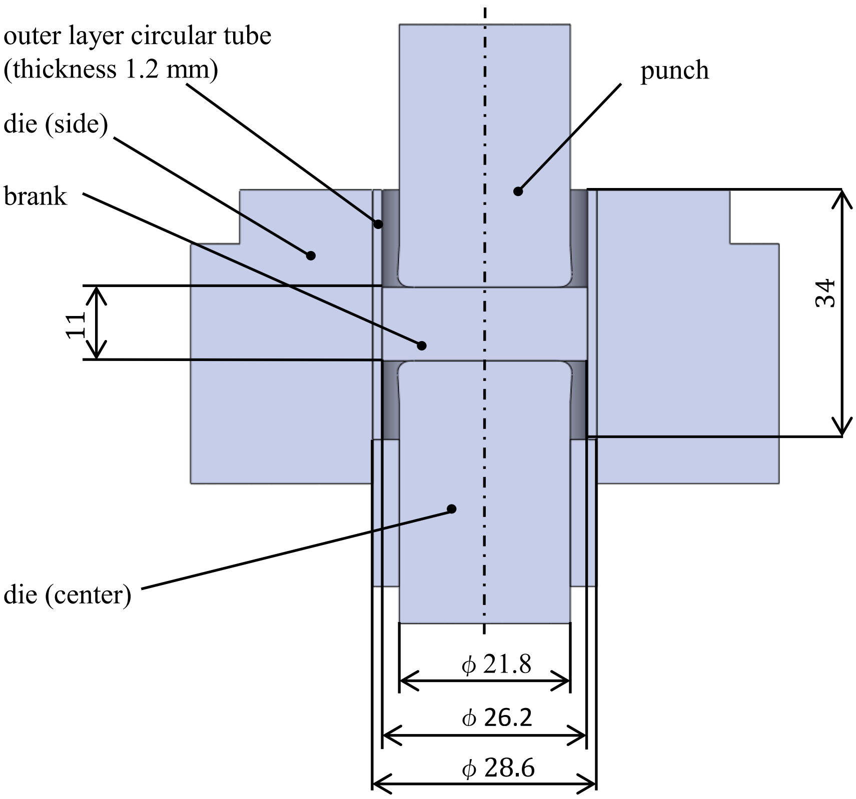
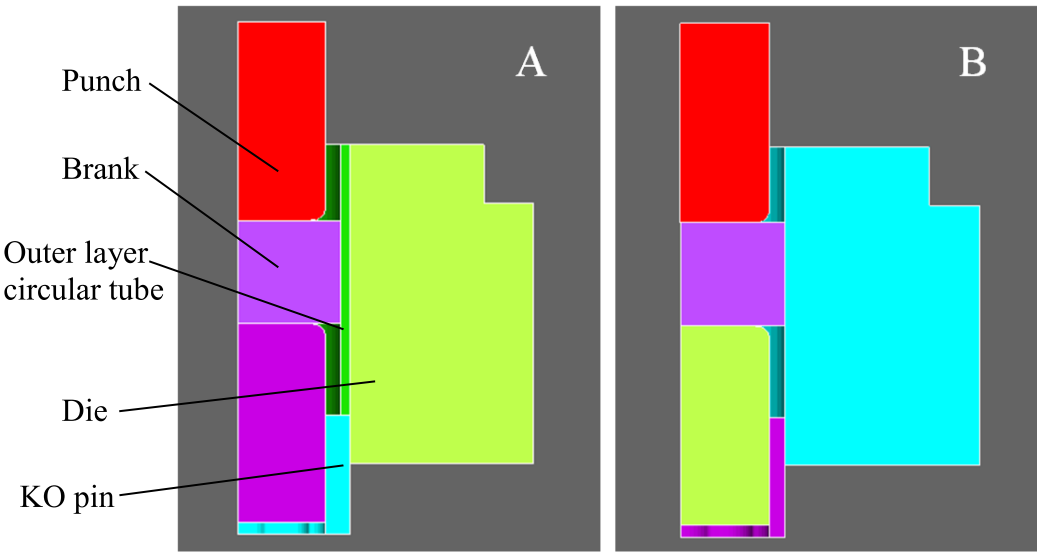


Figure 1: Model of double layer circular tube



(A) There is an outer layer circular tube (B) There is no outer layer circular tube

Figure 2: Differences in analysis conditions (Axisymmetric model)

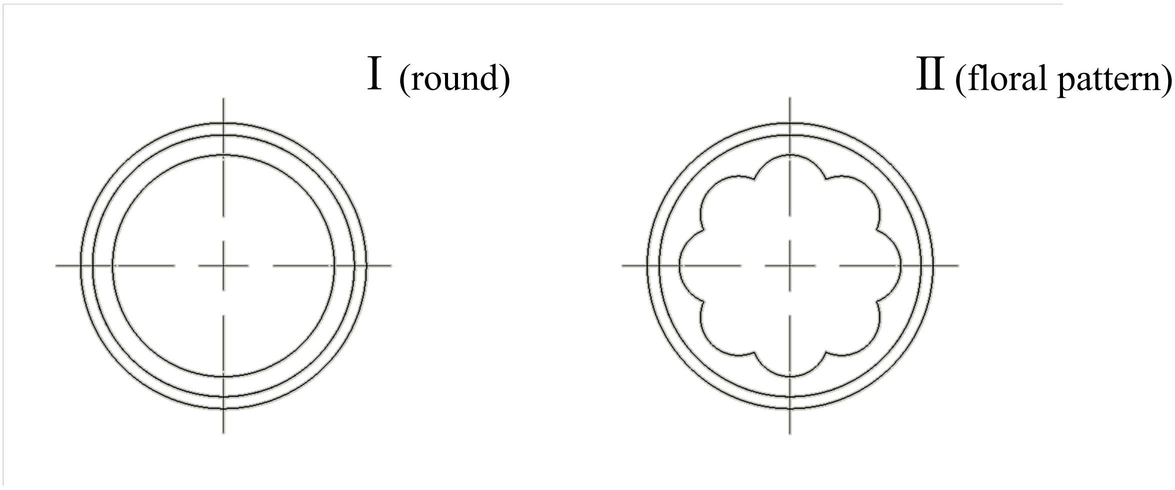


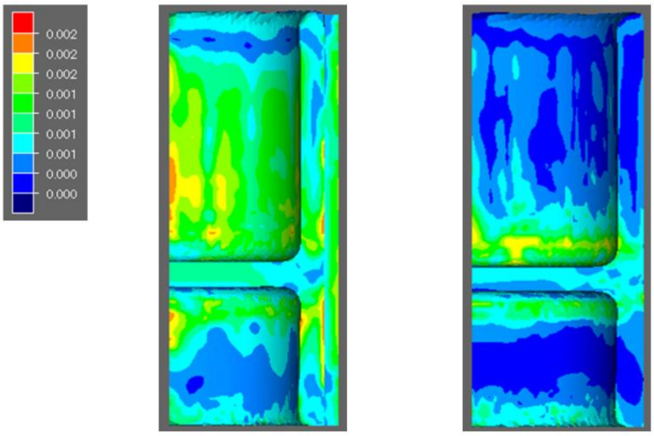
Figure 3: Inner shape of inner layer circular tube

Table 1: Dimension and material of circular tube

	Outside diameter [mm]	Inside diameter [mm]	Length [mm]	Material
Cylindrical blank (floral pattern)	ϕ 26.2		11.5 (13.0)	A1100 (JIS H 4100)
Outer layer circular tube	ϕ 28.6	ϕ 26.2	34	STKM11A (JIS G 3445)

3 RESULTS AND DISCUSSION

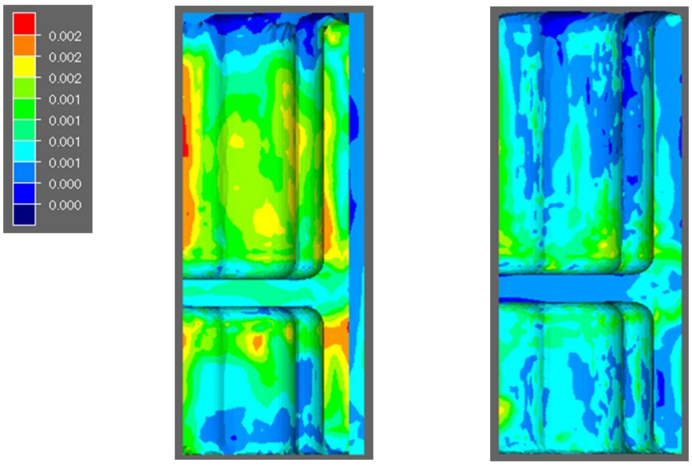
Figures 4 and 5 show the results of analysis of the equivalent elastic strain after the punching and die removal at the end, with the Forward and backward extrusion at the punch speed of 10 [mm/s]. Figure 4 shows the results when the inner shape of the inner layer circular tube is circular, Figure 5 shows the result when the inner shape of the inner layer circular tube is a floral pattern. Figure 4(a) and Figure 5(c) show the results when the outer layer circular tube is present, and (b) and (d) are the results without the outer layer circular tube. Comparing Figure 4 (a) and (b), (a) has equivalent elastic strain in the position where the inner layer circular tube and the outer layer circular tube are in contact. On the other hand, in the case of (b), there are many parts where the equivalent elastic strain is close to zero. From this, it can be seen that in Figure 4 (a) the outer layer circular tube impedes elastic recovery of the inner layer circular tube, so that the outer layer circular tube is tightening the inner layer circular tube. Next, when comparing the case of the floral pattern shown in Figure 5, there are some differences in the strain distribution, but in the case of Figure 5(c) elastic strain remains at the contact part between the circular tubes, the same result as in the case of a round was obtained.



(a) There is an outer layer circular tube

(b) There is no outer layer circular tube

Figure 4: Difference in equivalent elastic strain due to the presence or absence of outer layer circular tube (Round)

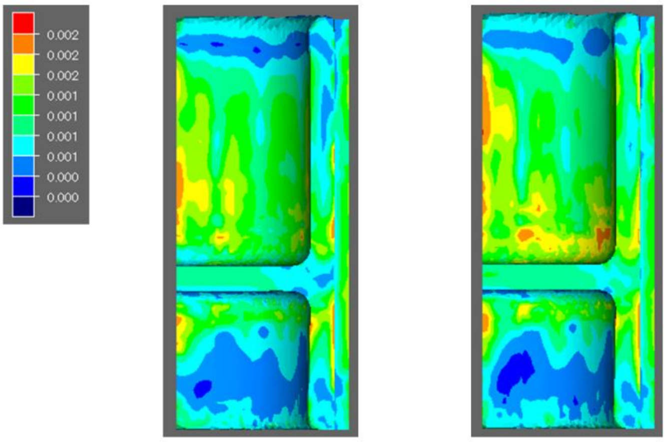


(c) There is an outer layer circular tube

(d) There is no outer layer circular tube

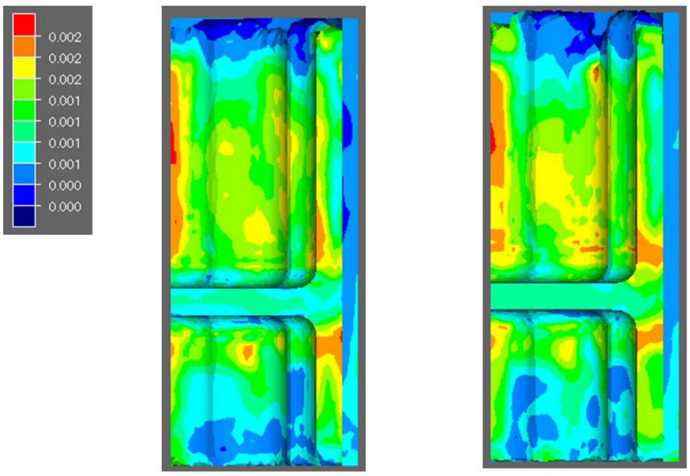
Figure 5: Difference in equivalent elastic strain due to the presence or absence of outer layer circular tube (floral pattern)

Also, as a result of examining the influence of the punch speed on the formability of the two layer circular tube, the results shown in Figure 6 and Figure 7 below were obtained. Figure 6 and Figure 7 are the analysis results of the equivalent elastic strain for punch speeds of 10 [mm/s] and 50 [mm/s]. Figure 6 shows the result of the inner surface shape of the inner layer circular tube being circular, and Figure 7 shows the result of the inner shape of the inner layer circular tube being a floral pattern. Figure 6 (a) and Figure 7 (c) show the results of the punch speed of 10 [mm/s]. Figure 6 (b) and Figure 7 (d) show the results of the punch speed of 50 [mm/s]. From Figure 6 and Figure 7 it can be seen that there are parts where equivalent elastic strain remains at the contact part between the inner layer circular tube and the outer layer circular tube respectively. As a result of comparing the equivalent elastic strain, the range of equivalent elastic strain corresponding to the outer circumference of the inner layer circular tube is wider in Figure 6 with higher punch speed. For this reason, I think that fast punching speed is good with regard to tightening. The same result was obtained for Figure 7 which is the case of the floral pattern.



(a) Punch speed 10 mm/s (b) Punch speed 50 mm/s

Figure 6: Difference in equivalent elastic strain due to punch speed (Round)



(c) Punch speed 10 mm/s (d) Punch speed 50 mm/s

Figure 7: Difference in equivalent elastic strain due to punch speed (floral pattern)

4 CONCLUSION

As a result of comparing the differences in the corresponding elastic strain due to the presence or absence of the outer layer circular tube, the value of the corresponding elastic strain at the contact portion between the outer layer and the inner layer was almost zero when there was no outer layer circular tube. On the other hand, when there was an outer layer circular tube, the result that the equivalent elastic strain easily remained in the contact part between the circular tubes was obtained. Therefore, it can be seen that the outer layer circular tube is tightening the inner layer circular tube. Those with high punch speeds make it easier for equivalent elastic strain to remain corresponding to the outer periphery of the inner layer circular tube. In terms of tightening, it is better for the punch speed to be faster. A similar tendency was also observed when the inner shape of the inner layer circular tube was a floral pattern.

ACKNOWLEDGMENT

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