Proc. Schl. Eng. Tokai Univ., Ser. E
34 (2009) 39-42

Introduction of Three Departments Related to Mechanical Engineering in Tokai University and My research on "Easy-release Screw "

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Abstract

The outline of three departments related to mechanical engineering in Tokai University is introduced, and the educational goal and characteristics of each department are shown. As for the introduction of a study, the development of easy-release screw, which is comprised of a shape-memory alloy (SMA) washer and a screw, to facilitate the recycling of resources is presented. By controlling the transformation point of a wire, the processing temperature for shape-memory and the amount of bending strain, it became possible to fabricate washers which permit disassembling easily in a specified range of temperature.

Keywords: Departments related to mechanical engineering, Tokai University, Easy-release screw, Recycling

1. Introduction of Three Departments Related to Mechanical Engineering

There are eleven departments and two major courses in Engineering Faculty at Tokai University. Among them, the Department of Precision Engineering, Department of Mechanical Engineering and Department of Prime Mover Engineering are those related to mechanical engineering. The quotas of students of each grade are 80, 120, and 180 in the order of the departments described above. So, the quota of the students of each grade related to mechanical engineering totals 380. This is the largest quota level among all universities in Japan.

The educational goal and characteristics of each department are shown below.

a) Department of Precision Engineering

This department aims to train specialists in the field of precision machinery while concentrating on robots (Fig.1) , micro-machines, precision processing, and nanotechnologies.

b) Department of Mechanical Engineering

This department trains mechanical engineers from a broad and balanced outlook to develop graduates who can deal with with a wide variety of machines (Fig.1).

c) Department of Prime Mover Engineering

The goal of this department is to develop students with skills and knowledge related to automobile (Fig.1), motive power, and transportation machine.

The number of graduates of the departments related to mechanical engineering totals 20000 to date. Many of the graduates are active in the front lines in various fields and the many famous companies.

Fig.1 Developed and studied machines in departments related to mechanical engineering

*1 Professor, Department of Precision Engineering

2. My research on "Easy-release Screw "

2.1 Introduction

Recently, home electronic appliance and automobile recycling laws are being enforced, and the government is tackling strategies for the effective use of resources and environmental conservation jointly with the private sector. One problem, however, is that the number of home electronic appliances and automobiles to be disposed of is huge [1, 2, 3] and such recycling disassembly work shown in Fig. 2 is economically inefficient [4]. Therefore, we proposed new screws, i.e., easy-release screws, which are used with shape-memory alloy (SMA) washers to facilitate the recycling of resources. These screws are assembled by the conventional method. After disposal, the inside diameters of the washers are enlarged by heating the screws to a predetermined temperature, enabling the automatic disassembly of the screws (Fig.3).

In this study, the fabrication process for easy-release screws . with SMA washers (Fig. 4), and the functions and release mechanism of these screws were experimentally examined.

Fig.2 Disposed television and recycling disassembly work. (From EIC net and Sapporo City HP)

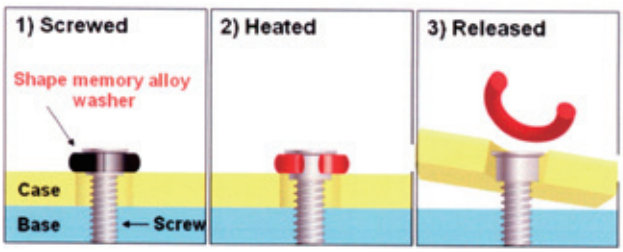


Fig.3 Mechanism of easy-release screw with shape-memory alloy washer

Table 1 Transformation temperature and diameter of tasted shape-memory alloy wire

No.	Material	Diameter d (mm)	Transformation Temperature Af (K)	Ms (K)
1	Ni-Ti	2.66	328	293
2	Ni-Ti	1.18	354	319
3	Ni-Ti	1.18	366	328
4	Fe-27%Mn-5.7%Si-5.0%Cr	13	473	253

2.2 Specimens and experimental procedure

Shape-memory alloys made of Fe, Ni-Ti, and Cu have the problem of low plastic workability [5-9]. The shape-memory characteristics of Fe alloy are inferior to those of Ni-Ti alloy. However, the Fe alloy is the most inexpensive and can be applied to temperatures higher than the transformation point of Ni-Ti alloy. Table 1 shows the wires used in this study, their diameter, A_f point, and the M_s point.

2.3 Development of easy-release screw using SMA wire

Figure 4 shows the fabrication process for a SMA washer and the appearance of an easy-release screw [13]. The easy-release screw developed in this study is the M2.6 screw used for small electronic appliances. Before the practical application of this screw, a sufficient fastening force of the screw must be ensured and the ease of release must be reliable. Resolving these issues requires the clarification of the relationship between transformation temperature and release-initiation temperature, determination of relationship between strains applied to the washer during fabrication and release-initiation temperature, and improvements in fastening force and reliability for washer release.

2.4 Relationship between heating temperature and inside diameter of washer

To clarify the properties of the fabricated SMA washer, a washer was placed in a dish filled with silicone and temperature was increased gradually as shown in Fig. 5 a).

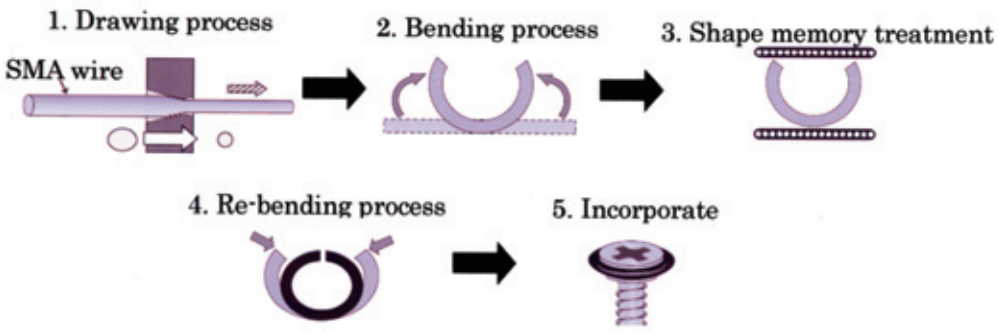
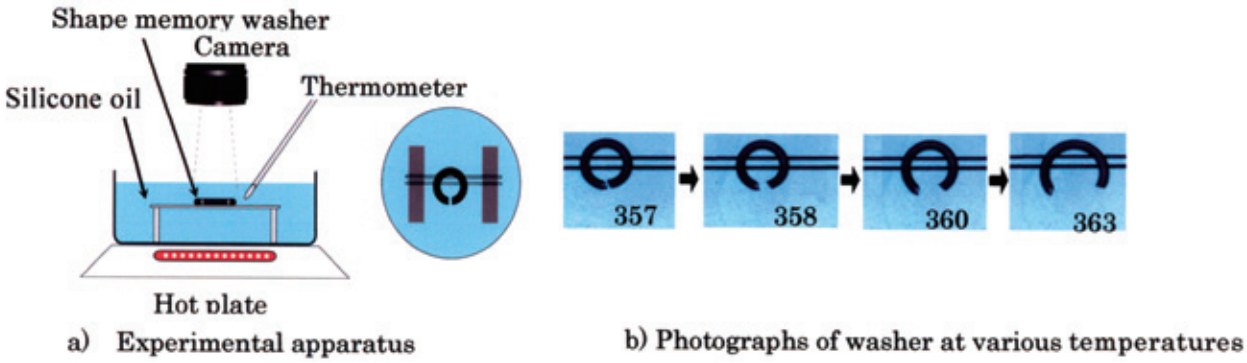


Fig.4 Fabrication process of SMA washer



a) Experimental apparatus

b) Photographs of washer at various temperatures

Fig. 5 Measurement of inside diameter of washer at various temperatures (inside diameter = 5.3mm)

The inside diameter of the washer was measured using a two-dimensional image measurement device (Mitsutoyo: Quick Image) set above the washer, and photographs of the released washers heated at various temperatures are shown in Fig. 5b).

Figure 6 shows the relationship between the temperature and inside diameter of the washer obtained in the washer release test under the same drawing conditions for washers fabricated using wires 1, 2, and 3, which have different transformation temperatures. When the temperature of the washer is increased, the inside diameter of the washer fabricated using the wire with a low transformation temperature starts to increase at low temperatures, leading to the release of the washer from the screw. In other words, the inside diameter (the temperature at which washer release begins) largely depends on the transformation temperature of the shape-memory alloy itself (A_f).

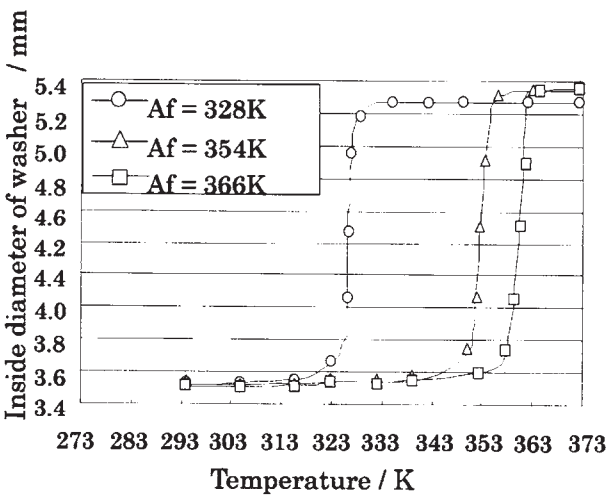


Fig.6 Changes in inside washer diameter on various transformation temperatures

In the fabrication process shown in Fig.3, the change in the inside diameter of the washer, ΔD, is calculated using the

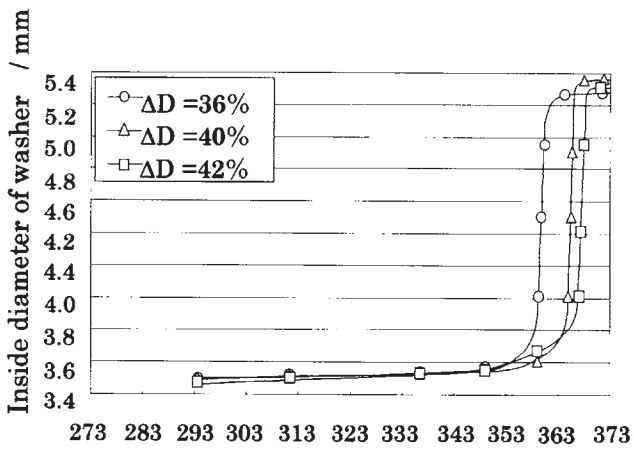


Fig.7 Changes in inside washer diameter with various bending strains of washer which is formed

equation (1), where the inside diameter of the washer at the temperature for shape-memory treatment is d_t and the inside diameter of the washer during the rebending process is d_f.

$$\Delta D = \frac{d_t - d_f}{d_t} \times 100(\%) \qquad (1)$$

Next, the washer release test was carried out using wire 3. Shape-memory treatment was carried out at a constant temperature 673K, while ΔD was changed (36, 40 and 42%) during the rebending process (Fig. 7). As shown in the figure, with increasing bending strain, the temperature at which washer release begins increases.

In order to examine the viability of using the Fe SMA washer and Ni-Ti SMA washer, a washer opening test was carried out, the results of which are shown in Fig. 8. It was found that the inner diameter of the washer increase gradually with increasing temperature. When the temperature reached 523K, the inner diameter of the Fe SMA washer indicated the maximum value.

On the basis of the discussions above, the temperature at which a shape-memory alloy washer is released and removed

from the screw predominantly depends on the transformation temperature of the shape-memory alloy wire. It was found that the temperature at which washer release begins can be controlled by changing the temperature of shape-memory treatment and the amount of bending strain.

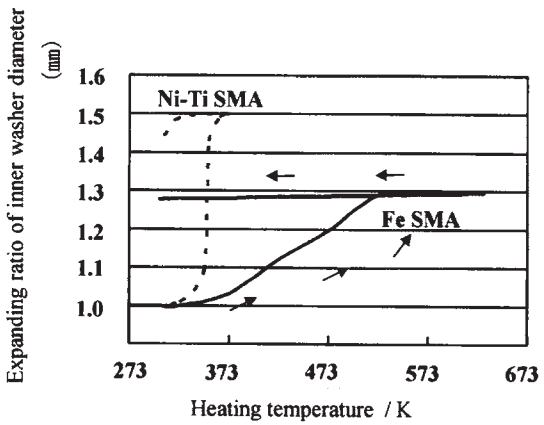


Fig. 8 Changes in inner diameter of washer with various heating temperatures

Our developed screw is already being utilized for some products, and their examples are shown in Fig.9. The developed easy-release screw is useful for the recycling of home electric appliance products.

5. Conclusions

Three departments related to mechanical engineering in Tokai University were introduced briefly.

And the developed easy-release screws using drawn shape-memory alloy wire was presented. Summings-up are as follows

(1) The developed easy-release screw is useful for the recycling of home electric appliance products.

(2) The temperature at which the release of a shape-memory alloy washer begins predominantly depends on the transformation temperature of the mother wire itself. By controlling the temperature of shape-memory treatment and the amount of bending strain, we can fabricate a washer that is made of a material having a different transformation temperature but can release at the same temperature..

(3) Though the performance of the screw using the Ni-Ti shape memory alloy wire is excellent, it is expensive.

(4) Fe shape memory is a promising material for high-temperature easy-realease washers with low cost.

Acknowledgements

Part of this study was carried out with the support of the University Venture Promoting Program by the Japan Science and Technology Center (JST). The author thank Mr. M. Tanigawa of Sharp Cooperation, Mr. H. Takahara of NEC Tokin Cooperation and Mr. K. Sugiyama of Union Seimitsu Cooperation for their valuable advice and support.

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a) Medical drip infusion equipment

b) Battery charger for cellular phone

c) Battery charger for phone

Fig. 9 Examples of practical application of the developed easy-release screws.