# THIN SHEET OF BRASS TESTING UNDER CYCLIC TENSION-COMPRESSION USING NOVEL ANTI-BUCKLING FIXTURE

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## 1. Introduction

Problems associated with material testing on flat specimens under compression within large deformation range procure many difficulties. It seems that the buckling is regarded as the most significant. Among many important phenomena observed during tests carried out on the flat specimens, which should be taken into account, one can distinguish:

- changes of the hardening modulus of a material due to variation of the loading direction,
- strain-hardening stagnation observed after change of the loading direction,
- relationship between strain amplitude and stress saturation,

Dietrich and Turski [1] elaborated in 1978 a solution of the side-supporting fixture. The main advantage of this design was an ability to support the entire specimen gage length during a test. This is due to the fact that side-supporting block was able to change its length together with a gradual shortening of the specimen during compression. In this paper, a modified version of the fixture was applied to execute experimental investigations of thin metal sheets under tension-compression cyclic loading. It enables application of cyclic tension-compression to the flat specimen in a wide strain range due to coupling of the side-supporting blocks with the standard grips of the testing machine. Design from 70’s could have been used only for monotonic compression since supporting blocks once shortened remained in this position. Another important advantage of the proposed design is the ability of monitoring a friction force between the specimen and supporting blocks, which allows avoiding an error during stress determination.

## 2. Experimental procedure

All tension-compression tests were carried out on thin sheet specimens with nominal thickness equal to 1 mm using the anti-buckling fixture presented in Fig.1, and described in detal in [2].

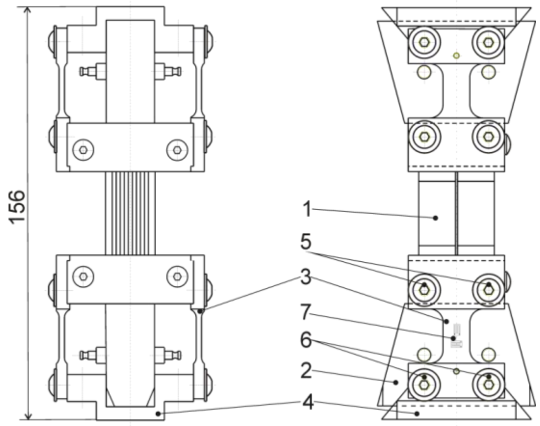

***Fig. 1.*** *Technical drawing of the fixture and numbered component parts as seen in front and from side*

Cyclic loading was carried out under displacement control with the rate 0.05 mm/s. Conditions on the engineering strain were set to limit strain range during cycling.

In the first type of test (tension – compression), 10 cycles within a strain range ±0.040 (strain varied between 0.02 and -0.02) were executed starting in tension direction. Last cycle ended with force equal to zero.

In the second type of test similar program was realized in compressive range of strain changing from -0.002 to -0.022. As in former case, 10 cycles were executed ending with zero force.

All tests were carried out using extensometer with a range of ±0.2. The load cell was calibrated in the range of ±25 kN. The special set-up for friction force measurements was applied. It consisted of two coupling bars with strain gauges calibrated in the range of ±2 kN.

## 3. Results

The results of first type of test carried out on the M63 brass under cyclic loading are presented in Fig. 2. The first cycle is illustrated by solid black line denoted as 1. The tensile stress–strain curve obtained under simple tension without the anti-buckling fixture usage is also shown in Fig. 5 (gray dotted line denoted as 2).

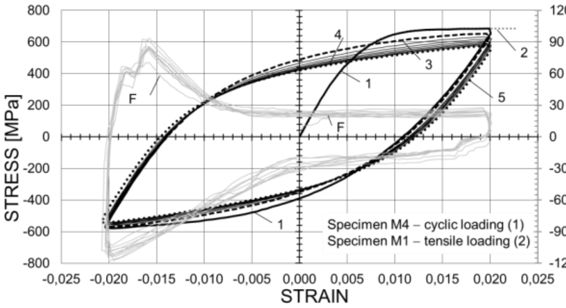

***Fig. 2.*** *Hysteresis loops of the brass and friction force variation during test*

A second cycle is represented by black dashed line (3). Last two cycles - denoted by black dotted lines (4 and 5). Figure 2 also presents an evolution of the friction force (gray lines, denoted as F). The friction force is also shown as a function of time in Fig.3 as well as total force for all recorded cycles. Changes of strain, corresponding to the force variations, are shown in Fig. 4 for all cycles carried out.

The brass exhibited softening effect reflected by a significant decrease of the stress amplitude, especially in the first two cycles, Fig. 3. A level of the friction force was also monitored during the test. Its variation is presented in Figs. 2 and 3. The friction force has a similar course in all cycles and does not change clearly under tension and grow up at compression. It has to be emphasized, however, that the values of friction force were relatively small and they did not change the cyclic stress-strain characteristic.

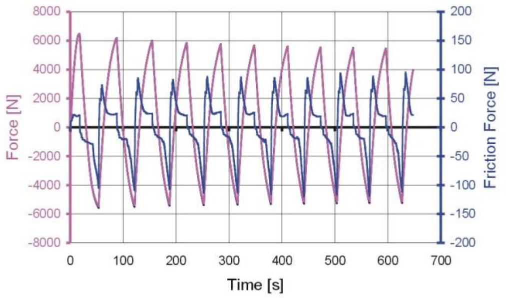

***Fig. 3.*** *Variation of the specimen load and friction force versus time during cyclic loading (test of type 1)*

In the second scheme of test the cyclic loading were performed for strain level varying between -0.002 and -0.022. Also ten cycles were carried out, however, in this case the loading process started in compression direction. The results of second type of test are presented in Fig. 5.

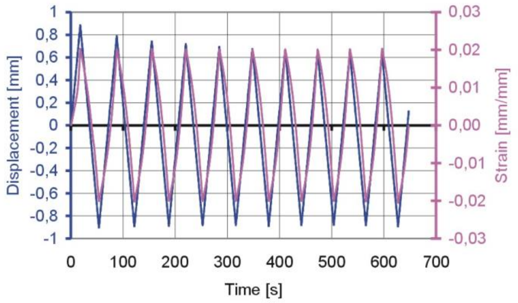

***Fig. 4.*** *Variation of displacement and strain versus time (test of type 1)*

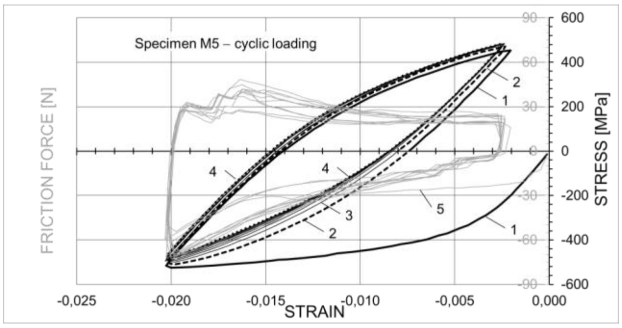

***Fig. 5.*** *Hysteresis loops of the brass and friction force variation during test*

The softening effect took place for the material in question. It is most remarkable for the first two cycles. During subsequent cycles the saturation state was almost achieved, i.e. hysteresis loops coincide themselves. The friction force had rather low magnitudes. As in the previous cases, the friction force variation data were subsequently used to correct the stress-strain characteristic of the brass tested.

## 4. Remarks

Problems associated with testing on flat specimens under large deformation are discussed. A new design of fixture for flat specimens testing is described. The results of investigations carried out on brass exhibit suitability of the fixture for tension compression tests in a wide range of strain.

## References

[1] Dietrich L., Turski K., 1978, A new method of thin sheets testing under compression (in Polish), *Engineering Transactions*, **26**, 1, 91-99

[2] Dietrich L., Socha G., Kowalewski Z.L., 2014, Anti-buckling fixture for large deformation tension-compression cyclic loading of thin metal sheets, *Strain International Journal of Experimental Mechanics*, **50**, 174-183