ANTI-BUCKLING SYSTEM FOR FLAT SPECIMENS INVESTIGATION UNDER CYCLIC TENSION-COMPRESSION

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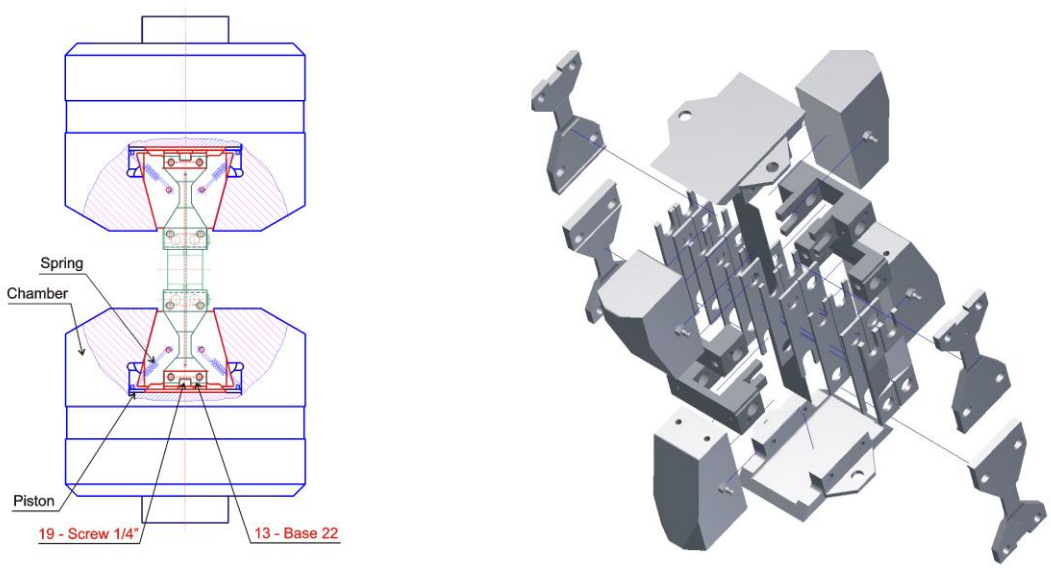
ABSTRACT - Problems associated with material testing on flat specimens under large deformation are discussed in this paper. An extensive review of the anti-buckling fixtures developed up to now is given first, and then detailed description of the proposed design is presented. Finally, the results of cyclic tests carried out using new fixture are studied.

INTRODUCTION: One of the first fixture dedicated for uniaxial compression of flat specimens was developed by Templin [ASTM E9-61]. In this fixture, a specimen was inserted between the steel rolls side-supporting it by spring loading. The most popular designs of the side-supporting fixture were built in the form of rigid blocks applying normal pressure to the flat specimen. Such rigid blocks were usually loaded perpendicularly to the specimen's surface using a spring or screw. Various modifications of such fixture differ in design of supporting blocks, side loading mechanism, strain measurement and test load application method. For all the fixture versions a specimen was longer than the side-supporting blocks by an amount necessary to obtain the required strain. Simultaneously, this amount was limited by the possibility of buckling. Fulfilling of two compromising requirements led to limit a strain range. On the other hand the strain range was also dependent on the specimen thickness which, in the case of very thin sheet, could limit significantly an attainable compressive deformation. As the matter of fact, a usage of this kind of fixtures reduced an active (gage) length of the specimen. In this paper, a modified version of the fixture developed in 70's [Dietrich and Turski 1978] 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.

PROCEDURES, RESULTS AND DISCUSSION: In Fig. 1 a scheme of the fixture is presented. It shows the fixture with mounted specimen and four clamping screws which establish friction force between the supporting plates and surface of specimen during tests.



(a) (b)

Fig. 1. Scheme of the fixture: (a) general view of the fixture mounted in the testing machine grips; (b) exploded view

A torque wrench was used for clamping screws during mounting of specimen in the fixture. Values of the torque moment were established by trial and error method in the preliminary tests. Three sub-assemblies of the device can be distinguished. The first, placed in the middle, consists of the side-supporting plates set, connecting pins and two pairs of yokes making two sliding blocks on both sides of the specimen. The side-supporting blocks attached to the specimen gauge part are composed in the form of thin plates with circular hole at one side and rectangular cut with semicircular end on the other. Neighboring plates are rotated with respect to each other by an angle equal to 180°. A pin fixed in the yoke joins thin plates with the same position. This assembly forms a variable-length side-supporting block attached to the gauge part of specimen changing length under applied loading. The length of a rectangular cut at one set of supporting plates and the overall length of those plates limit the strain range that can be executed. More details of this device can be found in [Dietrich *et al.* 2014]. The main part of the experimental programme consisted cyclic loading schemes. The tension-compression cycles were performed for strain level varying between 0.038 and -0.038 in the case of steel tested. Ten fully reversible cycles were carried out. The test started in tension direction. Stretching was continued up to the strain level equal to 0.038, and then unloading process took place and further loading under compressive conditions up to –0.038. Afterwards, unloading process was executed and again stretching up to 0.038. The sequence was repeated 10 times, Fig. 2.

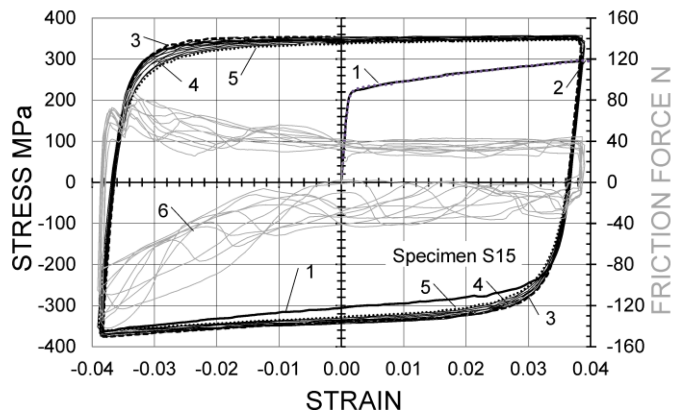


Fig. 2. Hysteresis loops of the steel and friction force variation during test

In Fig. 2 showing hysteresis loops of the steel, 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. 2 (gray dotted line denoted as 2). A second cycle is represented by black dashed line (3). The last two cycles - are denoted by black dotted lines (4 and 5). Figure 2 also presents an evolution of the friction force. Variation of the friction force measured by the special force sensor is represented as a function of strain for all cycles (gray lines, denoted as 6).

CONCLUSIONS: Application of the proposed measurement system enabled tension-compression tests to be performed at the displacement amplitude within the range ±5mm what corresponds to the maximum strain amplitude of ±0.4 for the specimen gage length to be equal 12.5 mm. It allows eliminating friction influence on the stress-strain characteristics.

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