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The Action of Variable Strains on the Remanent Tensions

The paper presents some general considerations on the action of variable straines on the remanent tensions, strain cycles, stabilisation tests after welding operations and welded metallic constructions subjected to vibration.

Keywords: *remanent tension, strain cycles, strains, welding operation*

1. General considerations

Shocks, vibroshocks, thermal strains, jolts etc. acting on the body trigger variable strains.

The variable strains induced in the interior of the material contribute to the increase of the local energy level, especially in certain high-tension level areas. This enables the apparition of certain dislocations in the crystalline structure leading to the formation of a more stable structure.

One has especially found that structure and shape stabilisation effects of the parts take place under the action of certain oscillating mechanical strains at the level of the flow limit.

Moreover such local overstresses may contribute to the reduction of the level of inherent tensions.

The correct analysis of inherent tensions existing in the material, of the reduced ones due to strain, as well as of the newly created ones due to these stresses is extremely difficult because of the interaction between the existing strains and the newly occurred ones. Moreover, they are usually considered to be homogenous environments with continuous distribution of inherent tensions triggered by the part shape, without taking into consideration the mircostresses in the interior of the material, which are supposed to mutually annul one another.

The explanation of the stabilisation mechanism under the action of certain oscillating strains is based on the property of metals to turn into heat the mechanical energy transmitted through vibrations and at strain levels situated below the macroscopic limit.

In different parts of the body microplastic deformations occur at tensions within the validity range of Hooke's law, which leads also to the reduction of the flow limit for fatigue tests.

Generally there are no modifications of the structures at low-amplitude strains. For plastic deformations big amplitudes are required.

In general the internal friction is not uniformly distributed in the interior of the crystalline structure, which is predominant in the non-homogeneous tension areas, as purely elastic oscillations cannot exist there. Due to the internal friction, in such non-homogenisation areas a superior energetic level is accumulated, enabling dislocations and important reductions of microtensions.

2. Strain cycles

In the case of variable strains we are interested in the variation of the characteristic dimension depending on time. We usually consider the plotting with the tension σ on the y-coordinate and the time t on the x-coordinate.

The variation within a period of the strain, supposed to be periodical, represents a strain cycle.

By definition the asymmetry coefficient of the cycle is:

$$R = \frac{\sigma_{min}}{\sigma_{max}}, \qquad (1)$$

If the tension permanently varies between the same extreme values σ_{min} and σ_{max} the strain will be considered stationary. This is the usual situation of variable strain through stationary cycles.

Taking into account the values and signs that the dimensions σ_{max}, σ_{min} and R can take, there are several characteristic types of strain cycles.

We call oscillating the cycles where the tensions remain of the same sense (positive or negative). We immediately remark that for positive oscillating cycles we have $0 < R < 1$, whereas for the negative ones we have $R > 1$.

The limit situations are obtained if one of the extreme tensions is annulled and these are the pulsating ones. For the positive pulsating cycle we have $R = 0$, and for the negative ones $R = -\infty$. In order to stabilise the shape of a part we applied strains, especially oscillating stresses produced by a pulsating device and their efficiency was monitored.

In fact, under the action of the variable strain there occurs a reduction of the permanent tensions. This also results from the diagram shown in Figure 1.

It follows that an important decrease of the remanent tensions takes place at a certain number of cycles, a little under 10^6, and in the range above $2 \cdot 10^6$ no further alteration can be noticed.

In general one considers that an important effect of tension reduction takes place only if the strain reaches a level of 0,8 σ_c where σ_c is the flow limit.

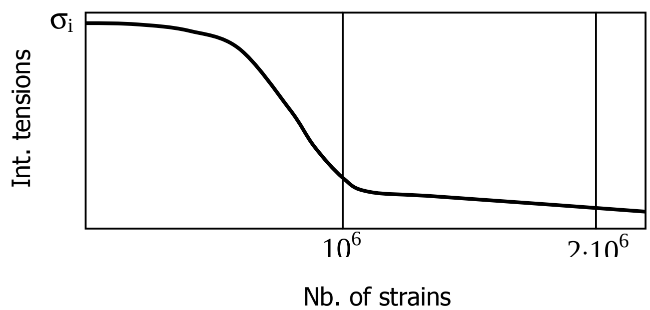

Figure 1

3. Stabilisation tests after welding operations.

The modification of the shape of certain deformed parts following welding may be performed through the action of the oscillating strain given by a pulsator. In order to highlight the effect of the variable strain one manufactured special samples in which deformations were produced by applying a welded seam. The influence of the strain level, as well as of the static component was shown following the modification of the arrows during tests. One used samples made of 0L 37. On the samples one has processed a V-shaped joint which was filled through multi-layer welding. Due to welding the samples bent, and different bending arrows were registered in the 14 tested samples.

Depending on the dimensions and the material of the sample one also established the strain degree, supposing the material flow limit σ_c, the acting forces were chosen so that they should perform a strain corresponding to a maximum tension σ_{max} ranging between 0.5 σ_c and σ_c , and respectively at a minimum tension σ_{min} ranging between 0.2 σ_c and 0.68σ_c. During tests one maintained a driving regime corresponding to a frequencies of 33.3 Hz.

The alteration of the sample profile subjected to the programme of testing at variable strains with positive oscillating cycles was determined on a verification table, after 500 and 1000 cycles respectively. The relative values of the arrows f/f_0, i.e. the ratio of the f arrow after a certain number of cycles and the initial f_0 arrow was represented in Figure 2, depending on the number of strain cycles. The measurements presented in the diagram of Figure 2 were performed after the testing, marked by a little circle, and 90 hours after the testing, marked by filled circles. One found that the efficiency of the shape alteration increases with the strain level. Obviously this confirms the hypothesis that for the establishment of the obtained shape a strain level reaching the value σ_{max} = 0,8 σ_c is necessary.

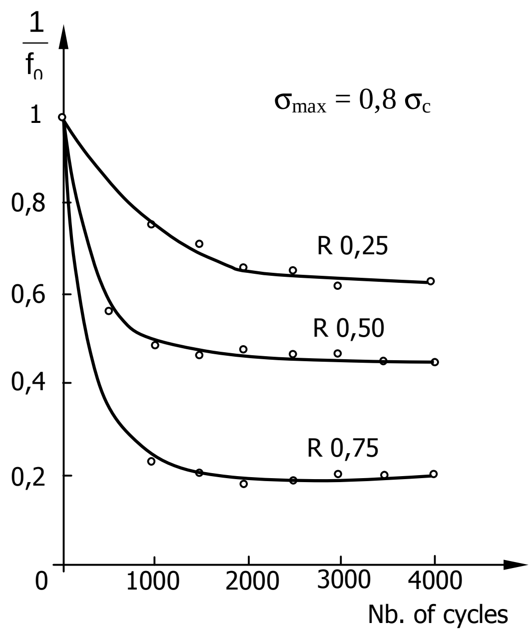

Figure 2

The tests effected at variable strains with positive oscillating cycles allowed the highlighting of the importance of the asymmetry coefficient R. For several samples the same strain level σ_{max} was realised, but with different values of the R coefficient, and arrows where measured as above, after a certain number of strain cycles [8].

What is determinant for the efficiency of the process of shape restitution and its stabilisation is the strain level, which assures efficiency only of it reaches the value $\sigma_{max} = 0.8\ \sigma_c$.

As the static component has a remarkable importance, it is necessary to apply also strains with the values of the asymmetry coefficient R which assures the necessary efficiency. It was proved that a relatively high asymmetry coefficient provokes a decrease of the number of cycles after which the stabilisation at a certain shape is achieved.

Except the intermediary states the process of shape alternation is irreversible. This stabilisation results from the analysis of the sample subjected to a high number of strain cycles. The arrow measured 164 hours after the cease of the tests corresponds to the values of the arrow established immediately after strain.

4. Welded metallic constructions subjected to vibration

In order to monitor the influence of vibrations on the tensions formed in metallic constructions due to welding, one initiated a testing programme using as generator a vibrator with built-in motor with the frequency of 50 Hz and amplitude of force of 2,800 N. Tests were performed on metallic welded construction made of angles with weight ranging 50-100 kg. In order to avoid natural detensioning the welding were performed immediately before the tests.

The testing programme was conceived with the purpose of establishing the duration of an efficient detensioning, the influence of the rigidity of the vibration fixing area on the structure and the influence of the asymmetry of vibration planes.

In view of eliminating any confusion one provided fixing measures on a large rigid support compared to the metallic constructions where one has tightly fixed also the rulers necessary for measuring the deformations.

The vibrator was fixed with the help of a device in different positions on the metallic construction subjected to the detensioning process.

Due to vibration, relatively important alterations appear in the geometrical shape. No modifications took place after a relatively short delay (maximum 9 minutes).

The tests pointed out the fact that one may obtain modifications of the strain states through mechanical vibrations. In order to increase efficiency, one found that the vibration planes realised through excitation should not be symmetry planes of the construction. Moreover, it is necessary that the application place of the vibrator should be rigid enough to transmit the vibrating motion along the welded construction.

Conclusions

In the mechanical structures driven from the exterior by a vibration source, these vibrations are transmitted in the mass of the structure according to the known transmission laws. Supposing the structure isolated from the environment, the energy given by the source of vibrations is consumed in order to effect the work of dislocations' shifts. The same phenomenon takes place also in the case of natural ageing, but more slowly, the energy being due to temperature variation and to random mechanical loads.

Globally one may appreciate that the unstable state of the structure compared to the stable one is characterised by greater internal frictions due to the shift of dislocations. Once this process concluded, when the internal amortisation of the structure is no longer modified, the amortisation becomes smaller than in the unstable state. This allows the appreciation of the degree of structure stabilisation based on the quantitative assessment of internal amortisation.

In general the stabilisation through vibrations leads to the relaxation of the structure, which corresponds to a decrease of distortions.

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