A REFINEMENT OF THE SHAPE OF THE TEMPERATURE CURVE FOR CYCLIC LOADING OF METAL SPECIMENS

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Some results are described of investigations to refine the shape of the temperature curve obtained when the thermal effect in cyclically loaded specimens is fixed. It is shown that the thermal effect occurs from the first loading cycles and not after application of a number of cycles, as previously assumed. A correlation is established between the temperature curve (its shape) and the shape of the curve for the change in the internal friction and the change in the bending of the specimen under cyclic loading. On this basis it can be stated that the shapes of the above curves indirectly describe the same changes in the metal when it is subjected to cyclic loads.

The author of [1], in his study of the thermal effect for cyclic loading of metal specimens, noted that there was an initial loading stage defined by the absence of the thermal effect. This is connected with the fact that a certain number of loading cycles has to be applied to the metal to activate the dislocation generators. The occurrence of such a stage and the hypothetical interpretation of the reasons for its existence are debatable. We know that from the very first loading cycles, irreversible physical processes occur which result in a weakening of the links in the crystal lattice [2]. Hence, to some degree, these changes must appear as a thermal effect, which was directly indicated in [3]: "... as soon as stresses, however small, begin to appear, at the same time heating occurs, although it is negligible." Hence the stage noted in [1] is objectively connected with insufficient sensitivity in the heat measuring system or with the positioning of the instruments.

To make the formulation of the problem more precise investigations were made on the thermal effect when laminar specimens are subjected to cyclic loading, the shape and dimensions of the specimens being similar to those described in [4]. The heat was measured by a differential thermocouple using a specimen as a component part of the measuring system, while the temperature curves were recorded automatically using a Kurnakov photorecording pyrometer. The exceptionally high sensitivity of the differential thermocouple (according to the data of [5] it makes it possible to detect temperature differences at two points of

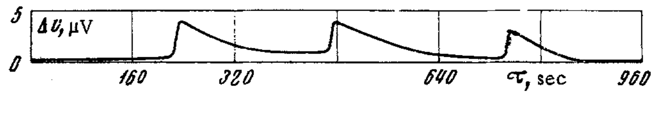

Fig. 1

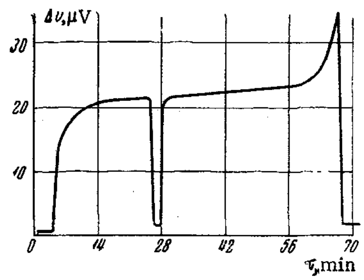

Fig. 2

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tenths or even hundredths of a degree) and of the mirror galvanometers of the Kurnakov pyrometer, and also the position of the thermocouple junctions on the specimen under investigation close together made it possible to obtain very sensitive and precise results virtually independent of temperature fluctuations in the surrounding medium. Fig. 1 shows a recording of the temperature curve (Δ is the difference in thermo-electromotive force at two control points on the specimen) when a specimen of Kh18N10T steel is subjected to the first three cycles of a loading in which the cycle load is 24 kg/mm^2. The load cycle takes 2 sec. The subsequent load cycles occur after the light signal of the galvanometer has returned to its original position and is stabilized.

Fig. 2 shows the temperature curve obtained from an experiment on the destruction of a specimen of 08KP steel for $\sigma = 1.2\ \sigma_{-1}$ with a two minute interruption in loading. The shape of the curve after repeated resumption of loading shows that the same form is preserved as occurred before the interruption.

It is significant that the temperature curve is completely correlated with the shape of the internal friction curve for similar materials (steel with a carbon content of 0.06%) [2], and also with the curve for the change in the bending of the specimen of commercial iron under cyclic loading [6], being its mirror image. Naturally, the shape of the temperature curve depends on the form of the cyclic loading on the metal.

Thus, if we use a highly sensitive measuring technique for the thermal effect in a cyclically loaded specimen, the load is fixed from the first cycles, which corresponds with the modern understanding of the nature of fatigue destruction. If we take into account the correlation of the temperature curve with the other curves describing kinetic fatigue destruction, the temperature method can be considered as one of the effective methods of investigating metal fatigue.

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