For weld joints the location of the crack in relation to the weld joint is very important. The maximum
growth rate of cracks parallel to the axis of the weld joint may be explained by the influence of the broad zone
of residual tensile stresses.

For cracks perpendicular to the axis of the weld joint a high growth rate is characteristic when their tips
are close to this axis. After the crack enters the zone of compressive stresses there is a decrease in the rate
d(2a)/dN.

Consequently, the reason for the decrease in the life of weld joints may be residual stresses. A change
in microstructure caused by welding is observed only near the weld joint and may not affect the growth of
creaks whose tips are not in the heat-affected zone. This is especially true of type W samples. At the
same time, it must be taken into consideracion that the average growth rate of fatigue cracks and, conse-
quently, life depends not only upon the value of the residual stresses [5], but also upon the form of their dis-
tribution. A broad zone of tensile stresses significantly decreases the life of weld joints.

LITERATURE CITED
1. W. Brown and J. Scrawley, Fracture Toughness Tests of High-Strength Metallic Materials in Plane De-
formation [Russian translation], Mir, Moscow (1972).
2. L. M. Shkol'nik, Rate of Growth of Cracks and the Tenacity of Materials [in Russian], Metallurgiya,
Moscow (1973).
3. S. E. Gurevich and L. D. Edidovich, "The rate of propagation of cracks and the threshold values of the
coefficient of stress intensity in fatigue failure," in: The Fatigue and Fracture Toughness of Metals [in
Russian], Moscow (1974), pp. 31-35.
(1963).
5. G. Glinka, "Wzrost pekniec zmgczeniowych w polu naprezen pozostajachch," in: Seventh Sympozjum
dosiadzialnych badan w mechanice ciata statego, Warszawa, 28-29 IX 1976.

AN INVESTIGATION OF THE LOW-CYCLE FATIGUE
OF HIGH-STRENGTH NODULAR IRON

Mukhamyankaka D. Bambanza

At present, cast irons having various modifications are being used more and more for the production of
highly loaded design elements. As a result, there is interest in cast irons with nodular graphite which are
widely used as a construction material and possess high mechanical characteristics.

In addition, some of these properties, in particular low-cycle fatigue, which is as known related to the
resistance to the action of cyclic stresses above the nominal yield strength, have received practically no study.

This article presents some results of experimental investigations of the low-cycle fatigue of nodular
iron.

The test samples were made of annealed nodular iron of the following chemical composition: 2.26% Si,
0.62% Mn, 0.048% Mg, 0.024% Ca, 0.21% Ni, 0.028% Ti, and 0.27% Cr. The basic mechanical properties of
the iron were \( \sigma_b = 55 \text{kgt/mm}^2 \), \( \sigma_{8.2} = 42 \text{kgt/mm}^2 \), \( \delta = 8.3\% \), and \( \varphi = 2.9\% \).

The samples were cylindrical with a gauge length \( L_g = 18 \text{ mm} \) and a diameter of \( d = 8 \text{ mm} \).

The tests were made on a machine built for this purpose in the Department of Resistance of Materials
of Kiev Polytechnic Institute using as a base a 10-ton lever tensile machine, making it possible to investigate
low-cycle fatigue in pulsating cyclic tension with continuous recording of the cyclic deformation curves on a
PDS-021M two-coordinate recorder. The experiment was made under soft loading conditions with a triangular
shaped cycle, a frequency of 1 cycle/min, and an asymmetry coefficient close to zero.

The experimental results to a base of $2 \cdot 10^3$ cycles made it possible to construct cyclic deformation curves, one of which is shown in Fig. 1. An analysis of the curves obtained makes it possible to separate out five characteristic portions (I-V).

In the first portion, which is related to the initial period of cycling from the first cycle to several cycles, a phenomenon is observed characterized by the fact that with an increase in the number of load cycles the increment in accumulated plastic deformation drops ($\Delta \varepsilon_{k+1} < \Delta \varepsilon_k$) while the hysteresis loops are open.

The second portion starts upon reaching a certain number of cycles (5-20), when the hysteresis loop becomes closed and accumulation of plastic deformations continues.

After a certain number of cycles ($\sim 100$) growth of the hysteresis loop is so retarded that the cycling process occurs almost at a constant plastic deformation.

The fourth portion is related to renewal of the accumulation of plastic deformation and the increment of plastic deformation starts to increase ($\Delta \varepsilon_{k+1} > \Delta \varepsilon_k$).

In the last and fifth portion there is opening up of the hysteresis loop and significant accumulation of plastic deformations. In some cases there has been noted a significant increment of plastic deformation with a constant maximum stress, which is indicated by a horizontal plateau on the cyclic deformation curves.

Figure 2 shows a low-cycle fatigue curve drawn to logarithmic coordinates on which two portions may clearly be seen. The first portion, the lack of failure portion or the quasistatic failure portion, covers a quite large portion which, obviously, is the result of nonuniformity of the iron and the spread in experimental data at the level of stresses equal to the tensile strength.

The second portion, the portion of cyclic creep or the portion of quasistatic fracture with a neck, is characterized by a continuous increase in the accumulation of plastic deformation with an increase in the number of load cycles. In this case this phenomenon occurs at stress levels of more than $0.896\sigma_b$. In cycling below this level the deformation process stabilizes and the accumulated plastic deformation remains constant until a certain number of cycles.

It should be mentioned that before failure of the sample there were no macrocracks on it and there was insignificant reduction at the point of rupture.

Cyclic creep curves 1, 2, and 3 (Fig. 3) are identical to the curves obtained for other materials [1]. For curves 4 and 5 there is a certain difference consisting of the fact that the portion of the curve characterizing steady creep is almost parallel to the axis of the parameter of life $N$ and the rate of creep in this portion is close to zero.

According to the data of [2], the amount of the maximum deformation accumulated before failure during cyclic loading depends insignificantly upon the number of cycles until failure. In addition, the deformation obtained in the case of cycling in tension-compression is equal to the deformation obtained in the case of rupture.