METHODS OF FORECASTING ARTICLES DESTRUCTION WITH APPLICATION OF ACOUSTIC EMISSION

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ABSTRAKT

In this article the authors offer methods and equipment based on the analysis of acoustic emission (AE) signals, appearing during the article´s operation, for forecasting of articles destruction in the course of their operation.

KEYWORDS

Destruction forecasting, acoustic emission, fatique loadings.

In the course of operation some principal units of different equipment is subjected not only repeated loadings, but also to substantial short-time overloads. Below we present methods of inspection and forecasting of destruction of articles operating under cycled loads with static overloads.

Methods has two variants: á) repeated loading with shor-time (3-5 min) cyclic testing load; b) repeated loading with testing overloads and different speeds of static loading. The testing was conducted with samples: length - 230 mm, diameter - 40 mm, steel (CT.20, CT.45 and 0X18H10T).

Repeated loading of samples was made by fatique machines UP-50. Testing static overloads were made by machines DM-30M (with manual drive and average loading speed 0.10 mm/s) and UM-5 (with electric drive and loading speed 0.333 and 1.0 mm/s) and dynamic loads were made by fatique machin UP-50. AE signals were registered by the instrument AF-15 and recorder H327-5.

In the course of testing the sensor of acoustic signals was located at side surface of the samples ant stack with elastic band. Acoustic contact was provided by lubrication of working face of the sensor with transformer oil.

The variant of methods of cyclic load of samples with shor-time overload was approved by sample from steel 20. In the mode of repeated-alternating loadings with with the stress

$\sigma=1.2\sigma_{-1}$ the samples were periodically (after each 50 thousand cycles) subjected to cyclic overloads with the stress $\sigma=1.7\sigma_{-1}$. The duration of overloads made up 180-300 s and loadings and unloadings continued 0.5 min. The diagram of load alternation depending on the number of operation cycles is presented in Fig.1a. The plot of samples stiffness (was evaluated by rela-

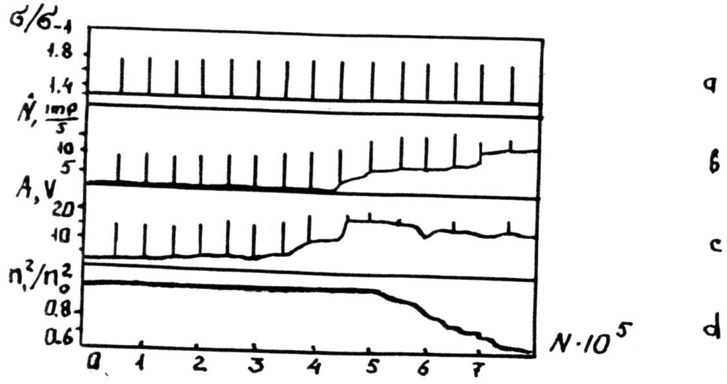

Fig:1.

tion n_1^2 and n_0^2) from the number of loading cycles is presented at Fig.1d, were n_1^2 and n_0^2 are initial and current values of engine shaft rotating frequensy of resonance fatique machine. Under all loading modes of articles was registered the amplitude (A) and count speed (Ṅ) of AE.

Typical results of alteration of registered values AE from the number of cycles are presented at Fig.1b and 1c. At the initial period of the samples testing it is observed low, practically zero level of count speed and amplitude AE. After $0.45*10^6$ loading cycles the parameters grow till the destruction of the sample.

Higher absolute values of AE parameters, reaching approximately constant values with number of cycles $0.45*10^6$ (count speed) and $0.35*10^6$ (amplitude) are observed under cyclic testing overloads. The rise of intensivity and maximal amplitude AE is connected with fall of the samples stiffness (Fig.1d), which is caused by the joining of microcrack into macrocrack.

Therefore under this type of cyclic loading with testing overloads, the AE parameters increase in comparison with the average level and reach approximately 120-200 thousand cycles till destruction of the article.

Nevertheless sign-changing testing overloads are not always possible in the course of the articles operation.

That is why we conducted investigations of variants of repeated loadings of the samples with their testing overloads. Samples from steel 45 were subjected to repeated increasing loading from $0.8\sigma_{-1}$ in steps 20 MPa and duration 10^5 cycles. After each step the fatique test of sample was interrupted and it was subjected to bending by static load till the yield point. For bringing the residual deformation to zero the samples were subjected to 3-4 cycles of static loading in the opposite direction.

Static loading and unloading of sample was made by mashine with manual drive (averidge loading speed 0.10 mm/s) in the course of 60-90 s. The duration of static loads was 90 s. It was established that with such static overload speeds the AE signal level was close to zero. It was offered to increase the loading speed.

Steel 0X18H10T samples were subjected to repeated-alternating loading from $\sigma=1.2\sigma_{-1}$ and $\sigma=1.3\sigma_{-1}$, and also to periodic (after each 100 thousand cycles) testihg static overloads with stress $\sigma=1.7\sigma_{-1}$. Static loading of samples by pure bending was made by machine UM-5 with speeds 0.333 and 1.0 mm/s. Static testing overload and repeated-alternating stress loading diagrams are presented in Fig.2 and 3 (static cycle duration made up 30 s.). The duration of article´s operation till the appearance of maximal intensivity was substantially dwindling with the increase of applying of static overload speed, as it appears from Fig.2 and 3.

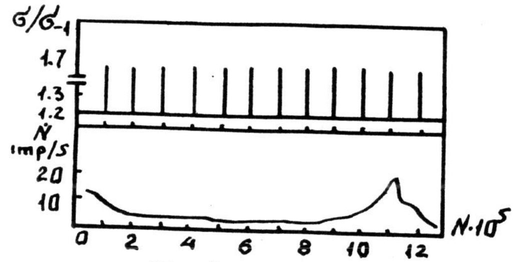

Fig.2.

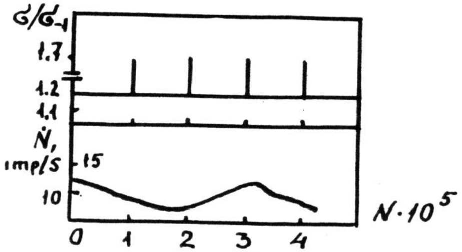

Fig.3.

Time analysis of AE speed´s variation shows, that with the first loading of sample, its accelerating growth is observed, explained by high density of movable dislocation and their gradual concentration near obstacles. Further the count speed is characterized by low or zero level in the course of the term, depending on the value of repeated-alternating stress. With formation of micrŏcracks and further joining into macrocrack the AE count speed increase is observed. After reaching the climax the fall (duration about 100 - 300 thousand cycles depending on the level of repeated-alternating stress) is observed after which the sample is destroyed.

On the basis of the results the principles of metholog construction were elaborated. For diagnostic parameter the AE count speed was chosed. For testing loadings it is preferable to use technological elements during the article operation, (e.g. heating-up and cooling modes with application of cold working environment on heated surfaces of steam generator elements).

The number of loading cycles in between testing loadings is chosen on the basis of real operation conditions.

In the result of the articles life testings (with artificial flaws if necessery) we received a series of curves showing dependence of AE count speed from the number of testing cycles. These curves are plotted on one chart, e.g. Fig.4. In the

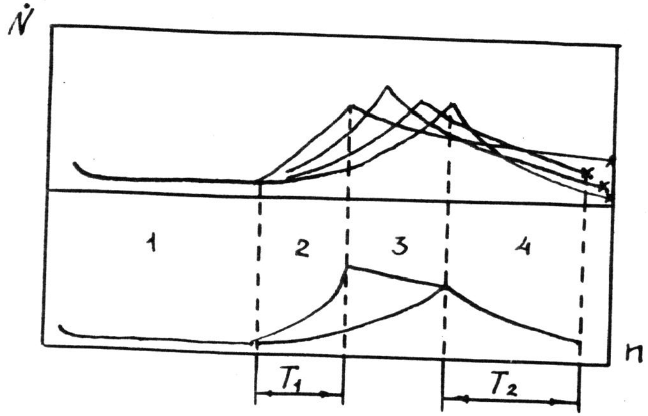

Fig.4.

chart there will be shown run-in zones 1, operation of normal article 2, beginning of crack formation 3 and further growth of macrocrack with dicrease of AE count speed 4.

In accordance with the results of life testing of articles models the criterion of the articles diagnostics is esteblished. From the beginning of operation till the beginning of increase of AE count speed the article is operable after diagnostics moment in the course of time period with duration T_1+T_2. After starting of AE count speed increase till reaching the maximum it is possible to guarantee the article's serviceability for the period after the diagnostics moment with duration T_2. The operation of the article should be stopped when at list two points with AE intensivity values are lower than in previous testing.

Therefore, the essence of this methodology of diagnostics is definition of the moment of limiting state, i.e. the state when further operation should be stopped for repair or replacement of the article.

In conformity with the methodology, the criterion of limiting state is stable decrease of AE count speed values, received in several periodical testing modes between operation cycles.