THE CRITERION FOR SELECTING THE LENGTH OF REALIZATION TO ESTIMATE THE MACHINES LIFETIME UNDER SERVICE LOADING

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To estimate the lifetime of machines and to make an informed decision about the accelerated fatigue testing, it is necessary to analyze the history of loading of machine parts in service. Currently there are at least two approaches for analyzing the service loading: 1) analysis of individual modes of loading and compiling the model block based on the share of operation in these modes; 2) global registration load for a long time during a representative period of operation. The latter approach proved to be technically feasible with the advent of microprocessors.

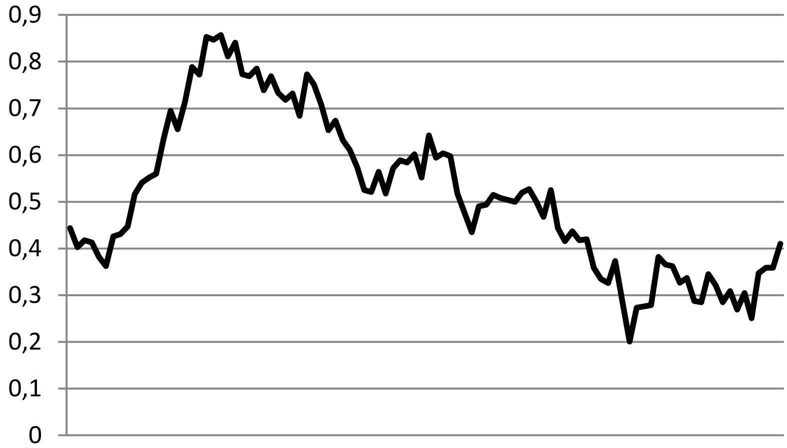
In both cases, there is the question of stationarity of the process of loading and of necessary length of realization. The definition of the stationarity in a wide sense was given by Alexander Khinchin. It is said that the random function is stationary if their mean value as well variance are constant, and the auto correlation function depends only on the difference of the times for which the ordinates of random function are taken. Unfortunately this definition gives little for estimation of properties of the random processes for evaluation of characteristics for lifetime assessment. It does not say anything about the required length of realization for estimation of characteristics of loading. Little could be said about the loading processes on the basis of spectral density because the properties of longevity correlate very weak with the frequency of the process. Here a new concept of stationarity of the process of loading in the narrow sense in relation to fatigue damage is proposed. It assumes the use of monitoring criterion for the estimated fatigue damage.

Loading processes of machines in service is likely to be a non-stationary random processes. It is known that the statistical parameters of the random process (mean value, variance, spectral density) do not correlate with the accumulation of fatigue damage. Representative convolution of the process is the distribution of amplitudes of full cycles. Since this distribution is only a supporting element for the assessment of machines lifetime L, this last is selected as the main criterion by which to judge the required length of realization. If the length of realization is large enough, the random effects are averaged and the calculated machines lifetime is stabilized. Let's consider a discrete chain of estimates of L*(t) of the lifetimes, which depends on the length t of the realization.

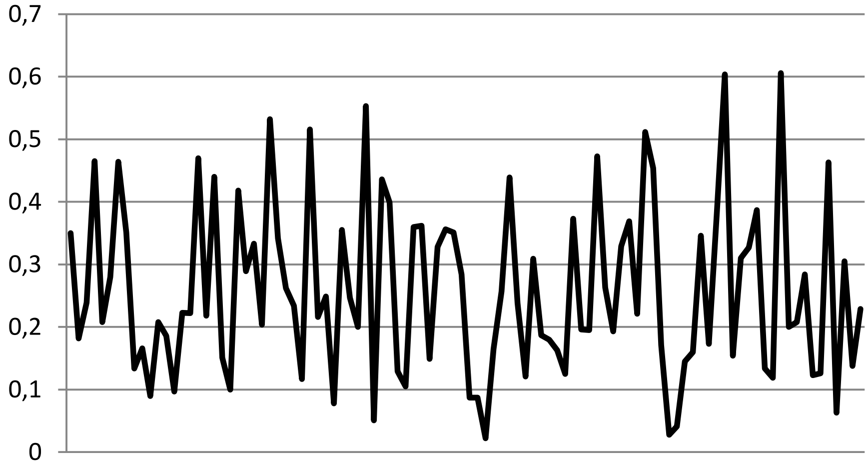
To analyze the effect of heterogeneity of the loading process of loading the monitoring of the results of estimated machines life time is used. When the realization becomes sufficiently long, random inhomogeneities are averaged, and the estimated lifetime is stabilized and tends to be a constant value.

The lifetime is calculated by the corrected linear hypothesis [1] with the reduction of the amplitudes of stress σ_a_ to equivalent ones taking into account the values of mean values of the cycles σ_m. Distribution of σ_a and σ_m is the result of cycle counting. That is the two-parameter rain flow cycle counting method. The algorithm of the three extremes [2] was used. The algorithm allows to update the estimator of L as information becomes available during service.

Two varied processes for investigation were selected [3]. The process A is wideband process with a small coefficient of irregularity ω=0,10. Here $\omega = N_0/N_e$, where N_0 is the number of intersection of the mean level, N_e is the number of extremes. The process C on the contrary, is narrowband process with ω=0,883. The coefficients of the fullness of their spectra V [3] are respectively V_A=0,676 and V_C=0,520. The parts of realizations of the normalized to unity processes A and C are shown on Pic.1 and Pic.2 respectively.



Pic.1. Part of realization of the random wideband process A.



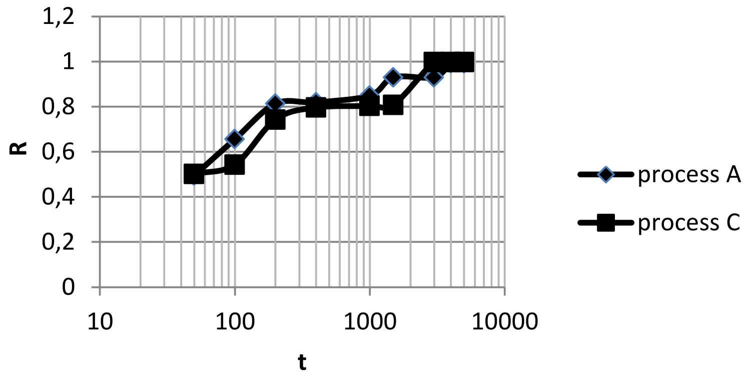
Pic2. The part of realization of the random narrowband process C.

The important characteristic of the process concerning the estimation of the lifetime is a maximum amplitude of the spectra σ_{amax} . If the mean value of cycle is not taken into account, it will be $\sigma_{amax}=R/2$, where R is the realization range. On the Pic.3 the ranges R for two processes are shown. For the process A stabilization of this parameter for process A is achieved at the realization length 4000 (that is about 1333 extremes) but for process C it is achieved at the realization length 3000 points.

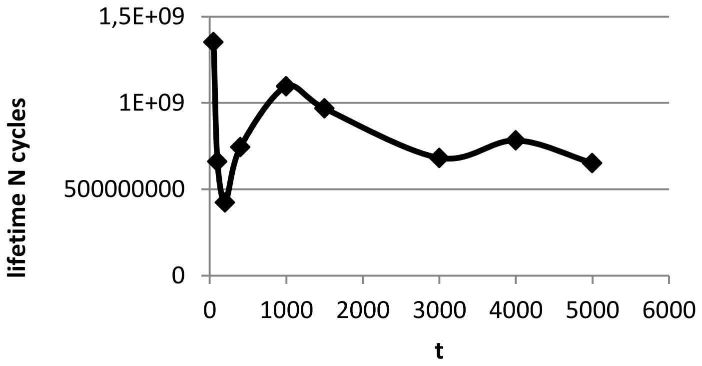
According the proposed approach on the Pic. 4 and Pic.5 the dependences of the estimated lifetime in number of cycles depending on the length of realization are shown. It can be seen that for narrow band process C the length of about 1500 is sufficient enough for the stabilization of estimated lifetime. On the contrary for wideband process A even the length 5000 might be not sufficient. For the estimation of lifetime the model fatigue curve for loading coefficient $n_p=\sigma_{amax}/\sigma_r = 1{,}1$ with slope coefficient m=5 was used. The correcting coefficient a_p of the corrected linear hypothesis [1] for simplification was taken as $a_p=0{,}3$.

Summary

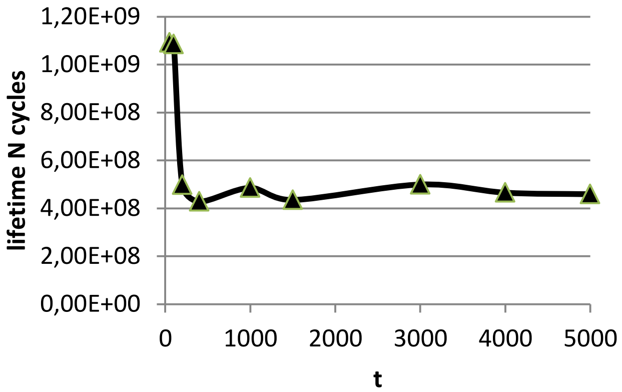
The wideband process requires the longer realization length that the narrowband one. The analysis of sufficient realization length according to the proposed approach is recommended.



Pic.3. Maximum range R of the normalized processes A and C depending on the realization length



Pic.4. Estimated lifetime L* as a function of realization length for the process A



Pic.5. Estimated lifetime L* as a function of realization length for the process C

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3. Savkin A.N. The steel damageability simulation under random loading by the power, energetical and strain fracture criterions / Savkin A.N., Sedov A.A., Andronik A.V. // Periodica Polytechnica, Mechanical Engineering. - 2014. - Vol. 58, Issue 2. - P. 119-126.