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DETERMINATION OF WORKING DYNAMIC STRENGTH, DISTRIBUTION AND SIZE OF SPILLING AT CALCULATION OF RELIABILITY

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ABSTRACT
Calculation of machine basic parts means to determine of calculation basic elements in the previous proceeding. It is working and critical stresses of parts, stress distribution, as well as, degree of overlapping the working and critical stresses. Working stresses of basic elements and their distribution are sizes which may be relative easy determined, as analytical so as experimental. However, determinations of distribution of critical stresses, spilling, as well as shape of distribution are very complicated if there is stochastic change of working stresses (working strength). By that, character of change of working stresses has essential impact on parameters of working dynamic strength.
In this paper it was shown how model of calculation of working dynamic strength, it distributions, as well as interval of result spilling, can be established. Results of established model are shown for material steel by type P-18A as material which is often used for manufacturing basic machine parts. Such proceeding and results can be used at calculation of reliability.
Keywords: working dynamic strength, size of spilling, calculations of reliability

1. INTRODUCTION
Based on reliability calculation of machine system basic parts means establishment of basic elements of calculation. Those are: work stresses distribution, critical stresses distribution and determination of degree of overlapping the working and critical stresses. If change of working stress is stochastic than working dynamic strength is element which is necessary for calculation. It presents critical stress. Opposite it, when changes working stresses are periodical, then basic strength is competent. Besides of working dynamic strength value and their interval of spilling from calculation aspect, shape of spilling is essential. It is different at different shape of working stress distribution (spectrum of working stress). In regards that spectrum of working stress distribution can be light, medium and heavy, and that each of them can be showed with suitable mathematical function, it is very essential to establish what kind of shape of working dynamic strength is in the different shape of spectrum. Also, it is important to analyze influence same spectrum of working stresses when affect on basic parts for different loads (bending, tension). Test of working dynamic strength of steel P-18A which is loading on bending for defined working stress spectrum was performed for establishing the parts of those unknowns. [1]. This steel is mostly use for production of rolling rolls.

2. WORKING DYNAMIC STRENGTH
Basic classification of critical stresses of dynamic stressed part, i.e. dynamic strength can be performed according to manner of stress changes. If changes of stress have constant amplitude σ_a, strength is basic strength and it presents the largest stress in cycle of stress changes. If those changes are more cyclic with different amplitudes σ_a, is strength is working strength and presents the largest stress during load changes. Working strength position in regarding to basic strength position is shown in diagram σ-N, Figure 1. As see, position working dynamic strength in regarding to basic strength,

for definite zone is moved in right, by that size of this movement is conditioned with participation of less than maximal stress i.e. with shape of working stresses spectrum.

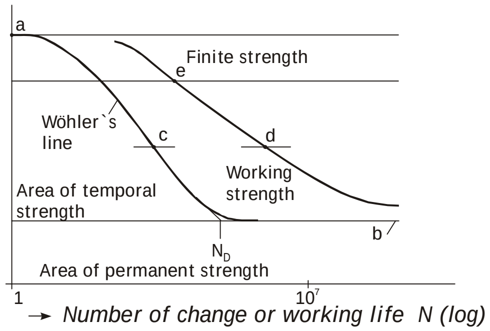

Figure 1. Survey of strength material type

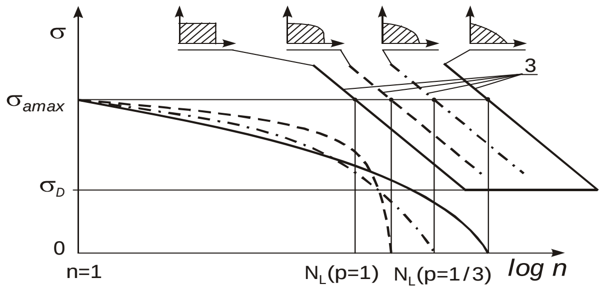

Figure 2. Working strength for different spectrum of working stress.

Influence of type of working stress spectrum on position of working dynamic strength for four different shape of working stresses spectrum line is shown on Figure 2. If basic part or tested test tube are loading with heavy working stress spectrum, position of working strength line is near basic strength, and if spectrum is light then working dynamic strength line is more distanced from basic strength [2].

3. ANALYSIS OF WORKING STRENGTH DISTRIBUTION

At setting up the working strength during testing is comes to results spilling, no matter what type is spectrum of working stresses. At testing of working strength result of that is number of cycle to break phenomenon *N* for defined level of maximal stress of given stress spectrum. Because, testing for given stress level is performing at other conditions, than from higher number of tests we obtained spilling of cycle number to break, i.e. spilling of life, Figure 3. With mathematics processing of spilling result distribution can be establish, Figure 4.

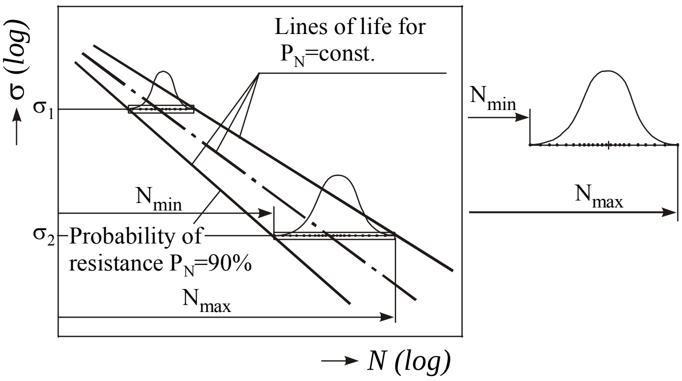

Figure 3. Spilling of number value of stress cycle N to break

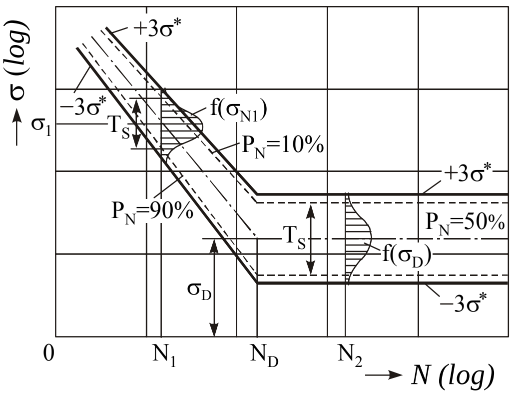

Figure 4. Spilling of dynamic strength value for number of changes $N_1$and N_2

Measure of spilling value of changes stress number is present as area of spilling N_p, i.e. difference between the least N_{min} and the largest N_{max} cycle of stress changes to destruction.

$$N_p = N_{max} - N_{min} \qquad ...(1)$$

By static processing of results can be established probability distribution low – density function *f(y)* and based of them can be set up probability of destruction P_R and probability of resistance, as:

$$P_R = F(y) = \int_0^y f(y)\ dy \qquad ...(2) \qquad\qquad P_N = 1 - F(y) = 1 - P_R \qquad ...(3)$$

Where: $y = (N - N_{min}) / (N_{max} - N_{min}), \qquad 0 < y < 1 \qquad …(4)$

N – cycle number of change of stress its suitable size of variable *y*.

On the basic of results of testing is possible perform exactly and simplify calculation of probability of destruction [3].
Probability of destruction for some number cycles *N* present a ratio of destroyed test tubes whose number of cycles to destruction is less or equal *N* to the number of total tested test tubes z_Σ while probability of resistance P_N may be defined as ratio of number no destroyed test tubes to some number of cycle of change of stress *N* according to expressions:

$$P_R = \frac{z_i}{z_\Sigma} \qquad \ldots(5) \qquad\qquad P_N = \frac{z_\Sigma - z_1}{z_\Sigma} \qquad \ldots(6)$$

By that sum of probability of destruction and resistance is equal to 1:

$$P_R + P_N = 1 \qquad \ldots(7)$$

As to demand for decreasing the costs and time of testing, number of tested tubes is rather small so the following expressions are used for determination of probability of destruction P_R:

$$P_R = \frac{z_i}{z_\Sigma + 1} \quad \ldots(8) \qquad P_R = \frac{z_i - 0{,}5}{z_\Sigma} \quad \ldots(9) \qquad P_R = \frac{z_i - 0{,}333}{z_\Sigma + 0{,}333} \quad \ldots(10)$$

Applying the previous expressions depends on estimation of conditions, test and size of area of spilling. They are used at first if number of test tubes $z_\Sigma < 20$.

4. EXPERIMENTAL TESTING OF WORKING STRENGTH OF MATERIAL P-18A

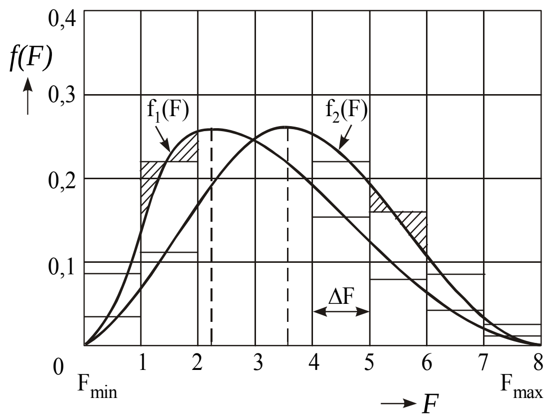

Figure 5.Mathematical shape of load function (stresses)

Size of working resistance and number of cycle of stress change to destruction depend on spectrum of distribution of working stress, or on shape of stress change in which relative participation of individual size of stress is met to relative participation of such stresses in spectrum of working voltage. As in this example researching the material is performed steel P-18A that is often used as material for steel rolls, sampling the material is done – test tubes were made and test shape of spectrum of working stress was defined, figure 5. There are two spectrums by different weights as they have different share of individual sizes of stress. Based on such spectrums test blocks were determined OB_1 and OB_2 [1]. Shape of test block OB_1 was shown on figure 6.

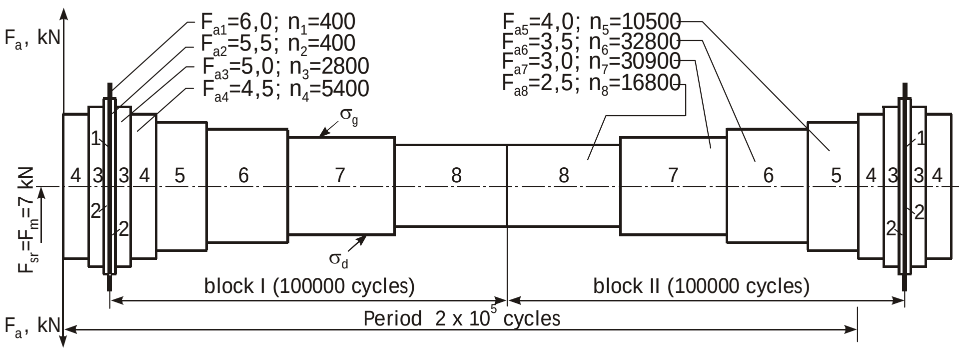

Figure 6. Test block of load of steel testing P-18A for OB 1

Results of tests of probability of resistance for optimal shape on pulsator are given in table 1, and graphical presentation is given on figure 7. If data processing is done from table 1, it may be set up that data on distribution of resistance are directly placed by line that presents Gauss distribution.

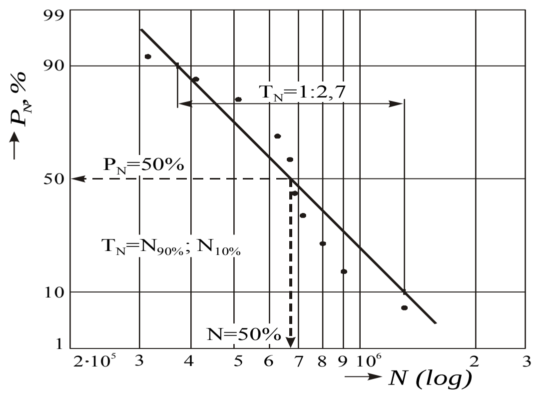

Figure 7. Distribution $P_N = f(N)$ according to test block OB 1, Figure 6.

Table 1. Probability of resistance results P_N for OB 1

Ord. No. of test	N	j	P_N, %
6	$3{,}40\cdot10^5$	n = 10	93,8
9	$4{,}07\cdot10^5$	9	84,1
3	$5{,}60\cdot10^5$	8	74,5
10	$6{,}07\cdot10^5$	7	64,8
2	$6{,}85\cdot10^5$	6	54,8
8	$6{,}86\cdot10^5$	5	45,2
1	$7{,}02\cdot10^5$	4	35,2
7	$7{,}94\cdot10^5$	3	25,5
4	$9{,}00\cdot10^5$	2	15,9
5	$12{,}50\cdot10^5$	1	6,2

Deviations that appear according to function of criteria C=95% are in limits of allowable. Based on this it may be concluded that for both spectrums of probabilities of distribution of stress may be shown by means of normal Gauss distribution, regardless to given spectrum of working stress. This is very essential founding during the calculation based on reliability as an element on distribution of critical loads.

Results of tests also confirm that for the first spectrum of working stresses, i.e. first testes block interval of spilling $T_N = N_{90\%} : N_{10\%} = 1 : 2{,}7$; and for second block $T_N = N_{90\%} : N_{10\%} = 1 : 2{,}1$.

If found results compare with those ones from literature it may be seen that in case of test block of load (OB1) wider interval of spilling of working dynamic strength has been got, while at larger participation of higher stresses (OB 2) closer interval has been got. By that at basic final working strength interval is the least. From those tests is obvious that for bars of cast material we have less spilling the material, i.e. closer interval of spilling, that for forged bars with notch [2].

5. CONCLUSIONS

Based on research on this work it may be concluded the following:

- Dynamic strength by constant stress change is basic, and at stochastic change is working strength.
- Spectrum of working stress has an increasingly influence to position and size as to basic as well as working strengths. Bigger participation of less stresses in spectrum, larger distance between working and basic strengths (σ-N).
- Shape of distribution of working stress has no influence to shape of distribution of working strength. In concrete example for steel P-18A for different shapes of spectrum Gauss's distributions of working strengths were set up.
- Shape of spectrum of working stresses has an influence to the size of interval of spilling.
- Found results can be used at calculation of reliability.

6. REFERENCES

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