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# IDENTIFICATION OF SOME MOTOR-CYCLE COMPONENTS RELIABILITY

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## Abstract

Modern technology has advanced the development of many new materials and products which in turn have created the need for new and advanced test methods. The material must be thoroughly investigated for mechanical properties such as fatigue life or maximum strength to permit efficiency and economy, as well as reliability and safe design of component structures. The method described in this paper deals with the stress distribution and application of statistical longevity of some motor-cycles components under operating the random loads. The results of its application are restricted to load-carrying motor-cycles components of small capacity.

*Keywords:* fatigue, statistical longevity, probability density function failure, reliability.

## 1. Introduction

Acquisition of the command with two-wheeled road vehicle for laboratory loading system contains identifications of the dynamic characteristic features in operating state, during random loads. The usual way to determine the equivalent loading of a random evolution is displayed in *Fig. 1.*

The signal of response may be analysed by statistical characteristic of stochastic function.

The random excitation of two-wheeled road vehicle is restricted to the random change of road surface undulations which provides a vertical input displacement into the tire of the vehicle.

The laboratory test is to simulate the dynamic response of the vehicle by subjecting each wheel at random varying displacement imposed by means of a simulator as shown in *Fig. 2.*

A motorcycle running along a road is subjected to two vertically imposed displacements, one at each wheel. The description of the road surface must be complete enough to describe adequately the displacement imposed at each wheel at least in statistical terms and the correlation between the two displacements.

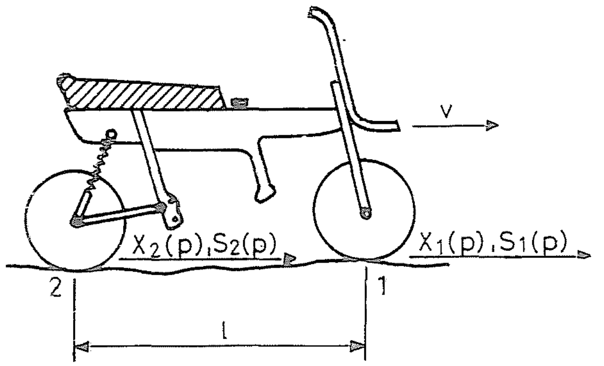


*Fig. 1.* Layout of inputs for a two-wheeled vehicle

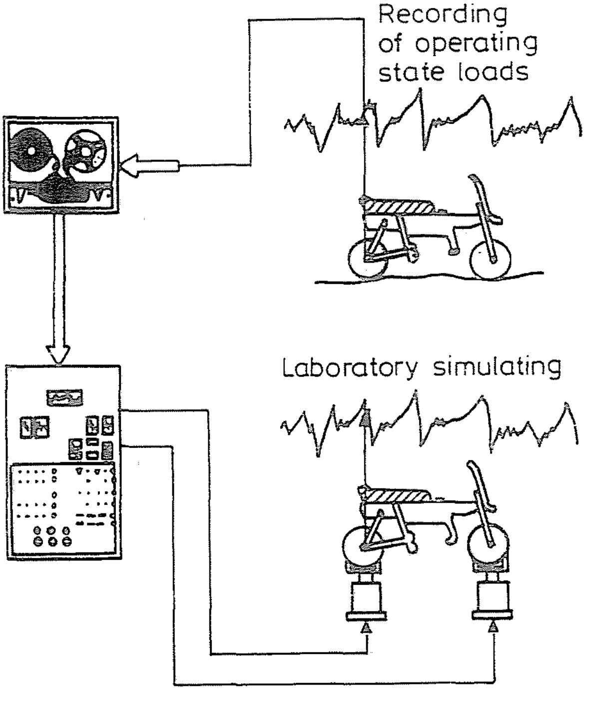


*Fig. 2.* Layout of laboratory test

## 2. Application of Statistical Longevity

The starting point of theoretical solutions reliability is the WEIBULL model [3]. The dependence between random loads and life, $N_f$, of components must be completed by a variable, $\mathbf{R}(N_f)$, which expresses digital quarantee in the probability form.

A three-parameters distribution may be expressed as

$$\mathbf{R}(N_f) = \exp(-((N_f - N_{\text{min}})/(N_{\text{sig}} - N_{\text{min}}))^k) \tag{1}$$

where: $N_{\text{min}}$ is a minimum of the longevity
$N_{\text{sig}}$ is a modal value of the longevity
$k$ is a parameter of distribution.

The probability density function related to (1) is of the form

$$f(N_f) = \frac{k}{N_{\text{sig}} - N_{\text{min}}} \cdot \left[\frac{N_f - N_{\text{min}}}{N_{\text{sig}} - N_{\text{min}}}\right]^{k-1} \cdot \exp\left(-\left(\frac{N_f - N_{\text{min}}}{N_{\text{sig}} - N_{\text{min}}}\right)^k\right). \tag{2}$$

The determination of the parameters of this distributions $\mathrm{k}, \mathrm{N}_{\text{sig}}, \mathrm{N}_{\text{min}}$ are achieved by the moment of function (2) numerically.

Common value of $n$-th moment for variables

$$\frac{N_f - N_{\text{min}}}{N_{\text{sig}} - N_{\text{min}}} \quad \text{is:} \quad \mathrm{m}_n = \Gamma\left(1 + \frac{n}{k}\right)$$

The first and second central moment of basic distribution *Eq.* (2) are:

$$\mathrm{m}_1 = \Gamma\left(1 + \frac{1}{k}\right) ; \quad \mathrm{m}_2 = \Gamma\left(1 + \frac{2}{k}\right) - \Gamma^2\left(1 + \frac{1}{k}\right).$$

The coefficient of obliquity is determines with second and third central of moment:

$$\frac{\mathrm{m}_3}{\mathrm{m}_2^{3/2}} = \frac{\left[\Gamma\left(1 + \frac{3}{k}\right) - 3\Gamma\left(1 + \frac{2}{k}\right) \cdot \Gamma\left(1 + \frac{1}{k}\right) + 2\Gamma^3\left(1 + \frac{1}{k}\right)\right]}{\left[\left(\Gamma\left(1 + \frac{2}{k}\right) - \Gamma^2\left(1 + \frac{1}{k}\right)\right)^{3/2}\right]}. \tag{3}$$

If we return to original variable $\mathrm{N}_f$, the first moment will be:

$$\mathrm{m}_1(N_f) = N_{\text{min}} + (N_{\text{sig}} - N_{\text{min}})^{1/k} \cdot \Gamma\left(1 + \frac{1}{k}\right) \tag{4}$$

and it is a reply to estimate the moment $\mathrm{m}_1(N_1)$ for basic random selection:

$$\mathrm{m}_1(N_1) \approx \mathrm{N}_S \tag{5}$$

where: $\mathrm{N}_S$ is a middle value of longevity.

The dispersion of original variable $\mathrm{N}_f$ may be expressed in a term:

$$\mathrm{m}_2(N_f) = (N_{\text{sig}} - N_{\text{min}})^{2/k} \cdot \left(\Gamma\left(1 + \frac{2}{k}\right) - \Gamma^2\left(1 + \frac{1}{k}\right)\right) \tag{6}$$

and the estimate of moment is

$$\mathbf{m}_2(N_f) \approx \mathrm{S}_N^2 , \tag{7}$$

where: $\mathrm{S}_n$ is the standard deviation.

From *Eqs.* (4) and (5) is:

$$\mathrm{N}_{\text{sig}} = N_S + \mathrm{S}_N \cdot A(k) . \tag{8}$$

From *Eqs.* (6), (7) and (8) is:

$$\mathrm{N}_{\text{min}} = N_S - S_N \cdot D(k) . \tag{9}$$

The application functions in *Eqs.* (8) and (9) are:

$$\mathrm{A}(k) = \frac{\left[1 - \Gamma\left(1 + \frac{1}{k}\right)\right]}{\left[\left(\Gamma\left(1 + \frac{2}{k}\right) - \Gamma^2\left(1 + \frac{1}{k}\right)\right)^{1/2}\right]}$$

and

$$\mathrm{D}(k) = \frac{\left[\Gamma\left(1 + \frac{1}{k}\right)\right]}{\left[\left(\Gamma\left(1 + \frac{2}{k}\right) - \Gamma^2\left(1 + \frac{1}{k}\right)\right)^{1/2}\right]} .$$

With parameters of distribution, we may define the result by the statistical curve of longevity, which in a form of probability characterized the longevity form *Eq.* (1)

$$\ln(-\ln \mathbf{R}(N_f)) = k(\ln(N_f - N_{\text{min}}) - \ln(N_{\text{sig}} - N_{\text{min}})) .$$

But for the case $N_{\text{min}} = 0$, the function of probability of longevity, *Eq.* (1), will be reduced to two-parameters of term:

$$\mathbf{R}(N_f) = \exp\left(-\left(\frac{N_f}{N_{\text{sig}}}\right)^k\right) . \tag{10}$$

The probability density function related to *Eq.* (10) is:

$$\mathbf{f}(N_f) = \frac{k}{N_{\text{sig}}} \cdot \left(\frac{N_f}{N_{\text{sig}}}\right)^{k-1} \cdot \exp\left(-\left(\frac{N_f}{N_{\text{sig}}}\right)^k\right) . \tag{11}$$

Estimates of parameters $k$, $\mathrm{N}_{\text{sig}}$ by characteristic value $\mathrm{N}_S$, $\mathrm{S}_N$ may be expressed:
from *Eqs.* (4) and (5)

$$\mathrm{N}_{\text{sig}} = \frac{N_S}{C(k)}$$

from *Eqs.* (6) and (7)

$$N_S = S_N \cdot D(k)$$

where: $\mathbf{C}(k) = \Gamma\left(1 + \frac{1}{k}\right)$.

The functions $\mathbf{A}(k)$, $\mathbf{C}(k)$, $\mathbf{D}(k)$ and $\mathbf{B}(k)$ in *Eq.* (3), are introduced for the practical application in *Eq.* (1) for variables $\frac{1}{k}$.

## 3. Experiment and Results

The applications of this method in this paper are restricted to load-carrying parts of motor-cycles of small capacity. Tests are frequently completed on construction subassemblies, such as they are shown in *Fig. 3.*

The results of laboratory simulating test for a frame construction are shown for illustration. The frame is the most important load-carrying part of a motor-cycle. The test of simulation regime for a frame construction has been made upon the special purpose machine in a laboratory.

The laboratory test has been made for 3 alternative frame contructions. Experimental results of the laboratory test are shown in *Table 1.*

Alternative A is seen to be the most reliable. The results of random excitation in operating state are to be seen in *Table 2.*

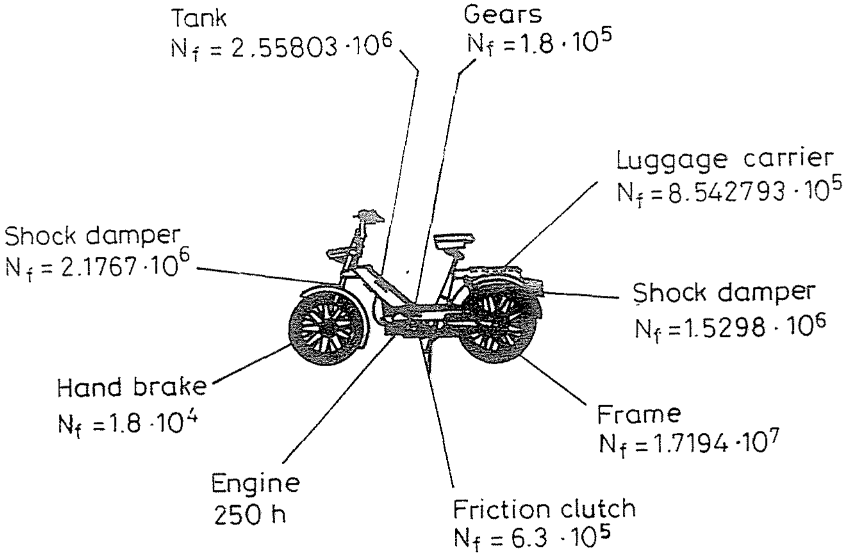


*Fig. 3.* View of the load-carrying parts of motor-cycles

The statistical curve of longevity for A alternative frame construction from *Eq.* (10) is shown in *Fig. 4.*

*Table 1.* Frame constructions

| Reliability: Number of cycles to failure | Alternative: A: | B: ×10$^6$ | C: |
|---|---|---|---|
| $N_{f1}$ | 22.4656 | 6.8759 | 12.1511 |
| $N_{f2}$ | 25.4133 | 1.2145 | 3.8624 |
| $N_{f3}$ | 22.4967 | 4.4231 | 1.8765 |
| $N_{f4}$ | 48.2970 | 4.0824 | 2.6661 |

*Table 2.* Frame constructions

| Statistical moment | Parameters of distributions | | | R($N_f$) % |
|---|---|---|---|---|
| $m_1 = 992.36$ | k | = | 1.062 | |
| $m_2 = 1690.24$ | $N_{sig}$ | = | $5.25701 \cdot 10^6$ | |
| $m_3 = 1346291.7$ | $N_{min}$ | = | $8.82048 \cdot 10^4$ | |
| | $N_f$ | = | $8.542793 \cdot 10^5$ | 0.9999 |

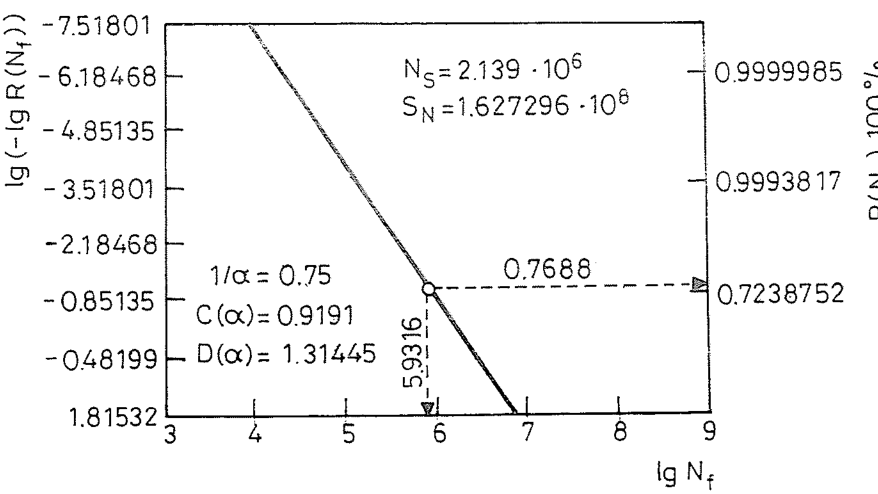


*Fig. 4.* Statistical curve of the longevity

*Eq.* (2) is an answer to the curves of probability density, from *Fig. 5* in our case for frames.

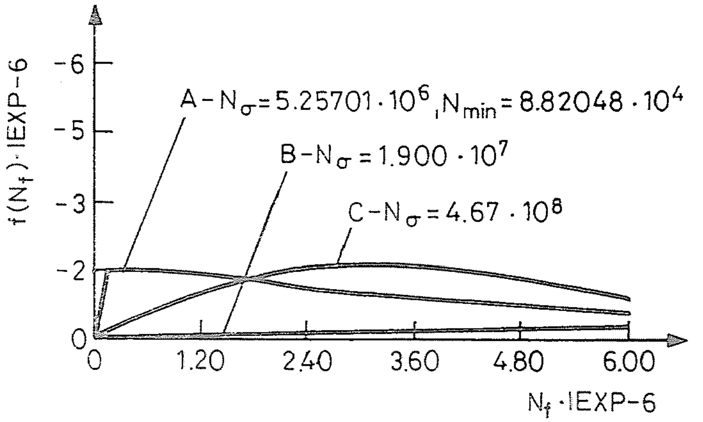


*Fig. 5.* Curves of probability density distribution

## 4. Conclusion

The test of the longevity of load-carrying parts of motor-cycles at laboratory makes variable extreme conditions of random excitation in operating state possible.

The application of this method shortens knowledge of the time to failure of machine components for transportation and contributes to the safety and economy of mechanical systems.

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