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INFLUENCE OF VARIABLE STRESSES ON THE STRENGTH PROPERTIES OF MATERIALS

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Abstract
In this paper the influence of variable stresses on the fatigue strength of parts used in mechanical engineering are studied. Also, the results of experiments carried out with different types of samples with different rounding radii and roughness under different loads are presented.

Keywords: fatigue strength, alternating stress, number of cycles, stress amplitude, roughness, symmetric cycle, pulsation cycle, cycle coefficient.

Introduction

Many machine parts experience stresses that change cyclically over time during operation.

Experiments show that at variable strength, after a certain number of cycles, the destruction of the part may occur, while at the same voltage unchanged over time, destruction does not occur. The destruction of a material under the action of repetitively alternating stresses is called fatigue failure. The main cause of fatigue failure is the cyclicity of failure [1, 2].

Let's consider some characteristics of the voltage that changes cyclically in time (Fig. 1).The cycle coefficient σ will be equal to: $\sigma = \frac{\sigma_{min}}{\sigma_{max}}$

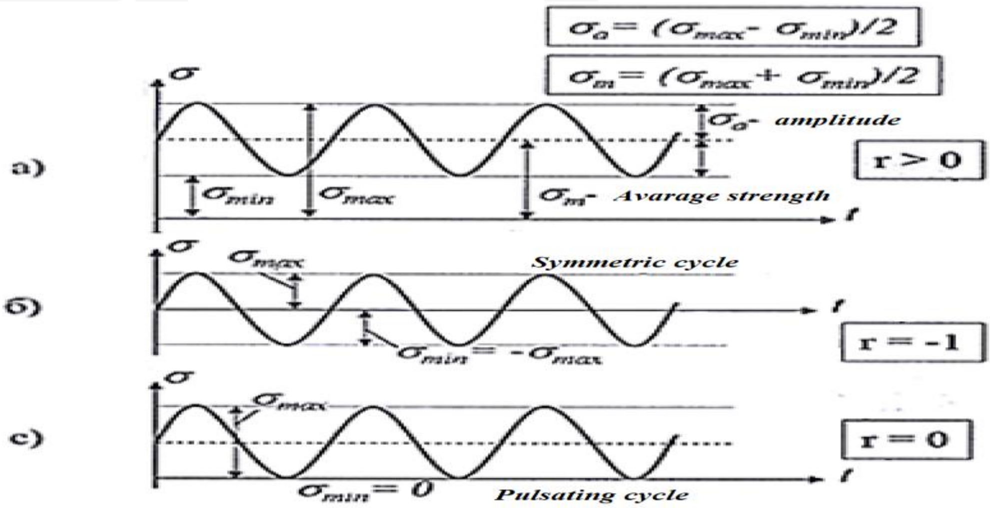

Fig. 1. Variable strength cycles

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In option 2, the strength changes not only the magnitude, but also the sign. Practice shows that this is the most unpleasant option for fatigue strength. Further experiments were carried out according to this variant. The tests were carried out on a WP-140 setup (Germany). Figure 2 shows the design of a fatigue testing machine. From fig. 3, the bending moment will be equal to following:

$$M_{bend} = F \cdot a, \text{ then } W_x = \frac{\pi d^3}{32}$$

The strength amplitude is determined by the following formula:

$$\sigma_a = \frac{M_{bend}}{W_x} = \frac{32 \cdot a}{\pi d^3}$$

where M_{bend} – bending moment, W_x – section modulus, d – sample diameter, F – concentrated force.

As can be seen from Figure 3, the most dangerous section is the section, where $M_{bend} = M_{max}$.

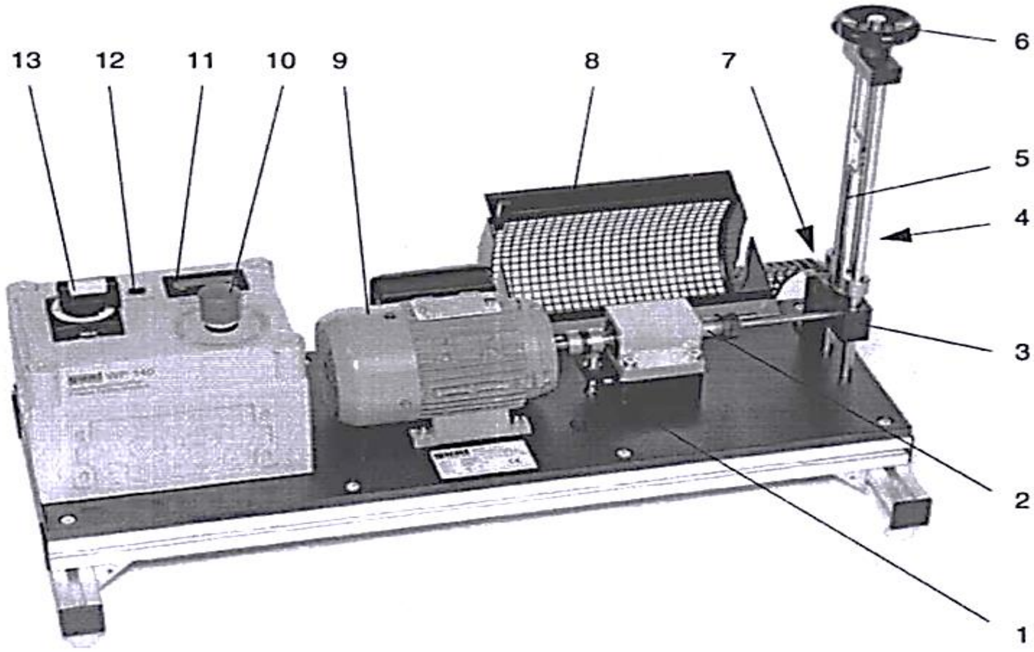

Fig. 2. Testing installation:
1 – sensor; 2 - spindle; 3 - floating bearing; 4 - scale (general);
5 - lever scales; 6 - flywheel; 7 - switch; 8 - protective cover;
9 - engine; 10 - emergency switch; 11 - counter; 12 - socket for connection WP 140.20; 13 - switch for motor protection.

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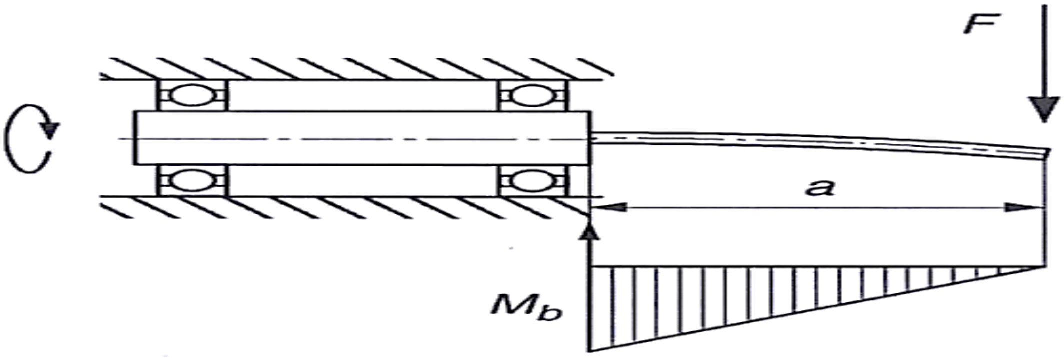

Fig. 3. Sample loading scheme.

The experiments were carried out with different types of samples with different rounding radii and roughness (Fig. 4). In all load cases F = 180 H, and σ_a= 360 N/mm².

The specimen to be tested is clamped in the spindle on one side with a collet chuck and inserted on the other side into the floating bearing (3). The sample is loaded using a spring balance (5) and a floating bearing. Load adjustment is carried out using a lead screw with a handwheel (6). The digital counter (11) registers the number of load cycles. If the sample breaks, the motor and counter are switched off automatically by the sensor.

Three types of samples were made from St20. They differed from each other in the rounding radius at the end and in surface roughness (Table 1). Three samples were tested for each type, then an average value was obtained.

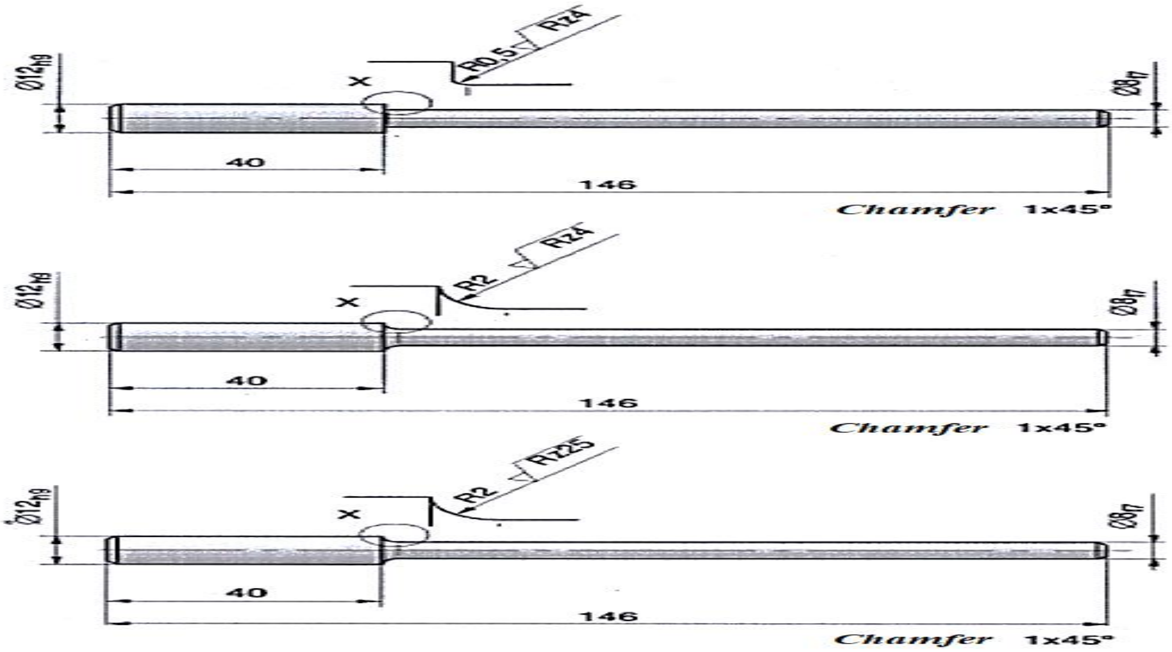

Fig. 4. Types of samples

Table 1. Sample condition

Type	Rounding radius	Surface roughness R_{tb}, Mm	Comment
1	0,5	4	Small radius, smooth surface
2	2,0	4	Large radius, smooth surface
3	2,0	25	Large radius, Roughness

The experimental results showed (Table 2) that the wear resistance of samples with a small rounding radius (type 1) is significantly lower than with a large radius. An increase in the roughness of the samples also leads to a decrease in wear resistance (type 3).

Table 2. Number of load cycles

Type	Sample 1	Sample 2	Sample 3	Avarage
1	12200	12200	12300	12233
2	18200	18300	1900	18500
3	15200	15300	15200	15233

Qualitatively similar data were also obtained at F = 140 H.
From the data obtained, it can be concluded that the wear resistance of parts operating under a sign-variable load is significantly affected by the rounding radius and surface roughness.

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