Description for the general public

The term *metal fatigue* first appeared over 170 years ago. However significant development of fatigue life research occurred in the 1950's. Since them a **consistent increase in the number of publications** has been observed, which have subsequently led to gradually learning about the essence of fatigue and solving succeeding issues related with the mechanisms of fatigue damage. However, despite a continually growing number of papers and the ever increasing interest of scientists of these mechanisms, up until now it has not been possible to, in an unequivocal manner to develop an effective method for predicting fatigue life.

The origin of this project was the thesis prepared by **Carpinteri – Spagnoli**, in which new criteria are proposed for multiaxial fatigue, where the critical plane orientation angle is expressed using two angles. The first is the maximum angle defined by normal stresses, and the second angle β, which is defined relative to the direction, assigned by the maximum in a normal direction and is expressed as:

$$\beta = \frac{3}{2}\left[1-\left(\frac{\tau_{af}}{\sigma_{af}}\right)^2\right]45^\circ \qquad (1)$$

Several years later in literature on the subject a proposal to express the mentioned angle appeared (relationship (1)), however each had its limitations.

The preliminary aim of the project is finding a **method**, which allows estimating fatigue life at the **design and construction phase** of machine elements and tools. In the newly proposed model estimated fatigue life, various angles of the critical plane were incorporated for many steel construction materials subjected to multiaxial operating loads during their use.

The estimated fatigue life in the case of multiaxial loads involves reducing this state to an equivalent uniaxial state with the aid of the appropriate criteria for multiaxial fatigue. In this project I will utilize and verify **multiaxial fatigue criteria** which are based on the concept of a **critical plane.** The concept of a critical plane assumes that material fatigue fracture is caused due to the effects of stress in the materials (critical) plane. In the project I plan to conduct variability analysis calculations of fatigue life depending on the value of the critical plane angle. I intend to conduct analytical tests, in which I assume that angle $\beta \in \langle 0^\circ\ 0.45^\circ \rangle$. For each of the 46 angles (1° increments) fatigue life will be calculated. In order to verify which β angle gives the most similar results, I will conduct a scatter analysis examining the dispersions of the fatigue life. I will conduct the calculations using results taken from literature as well as conducting **my own experimental research** (P91 or P92 steel) intending to verify the methodology assumption. I intend to conduct cyclical research of the multiaxial load at the MZGS100 work station.

The scope of the fatigue research will include:

- pure bending $\tau_a = 0$,
- pure torsion $\sigma_a = 0$,
- a combination of bending and torsion, for which the project load $\tau_a = 0{,}5\sigma_a$,
- a combination of bending and torsion, for which the project load $\tau_a = \sigma_a$,
- a combination of bending and torsion, for which the project load $\tau_a = 0{,}25\sigma_a$,

Results of the experimental research will serve in calculating and verification of the model.

The main reason for undertaking this topic is the noticeable lack in literature of models used to estimate fatigue life, which incorporates the critical plane angle for many construction materials. Furthermore an ever increasing group of new materials commonly used in industry require from designers increasingly broader general models incorporating such information. The new model will allow for better assessment of the fatigue life, subject to a multiaxial load, for a broader range of materials.