The XIV Finnish Mechanics Days 2022May 19–20, 2022,
Lappeenranta, Finland

Development of a large scale rotating bending fatigue testing machine

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ABSTRACT

The fatigue properties of a loaded solid are affected by its size through various mechanisms: Firstly, the existence of detrimental defects in the material usually follow a probability distribution giving rise to so-called statistical size effect. Secondly, the physical size of the geometrical features such as grooves and notches affects the size of the accompanying stress field and the crack growth mechanisms in it thus introducing so-called geometrical size effect. Thirdly, manufacturing methods (machining operations, heat treatments, surface finishing procedures etc.) for a given solid tend to be size-specific. For example, a large machine component and a small laboratory test specimen will likely have differences in their manufacturing process. When these differences affect the fatigue properties, so-called technological size effects arise.

It is important that size effects are considered in the analysis and design against fatigue, especially since fatigue properties usually decrease with increasing size of the solid but the bulk of the available test data is based on small-scale laboratory testing. Over the years, analysis methods have been developed especially for size-effects belonging to the first two categories mentioned above, the statistical and geometrical size effect. In contrast, the third effect, i.e., the technological size effect, tends to be case-specific and general conclusions are difficult to draw. This introduces a challenge in the case of machine components where high performance and high reliability are required; analysis based on small-scale laboratory testing data tends to lead to a non-optimal design unless time-consuming and costly prototype testing is carried out.

In order to narrow down the obvious difference in the size scale between laboratory testing and real-life applications, a large rotating bending fatigue testing machine (RBFM) was designed and constructed at Tampere University, see Fig. 1. This presentation focuses on the design aspects and operation of the device with special emphasis on the analysis of the specimen loading. It is noteworthy that some of the aspects discussed in this presentation are usually negligible in small scale testing, but become important as the size of the test specimen and the test device increases.

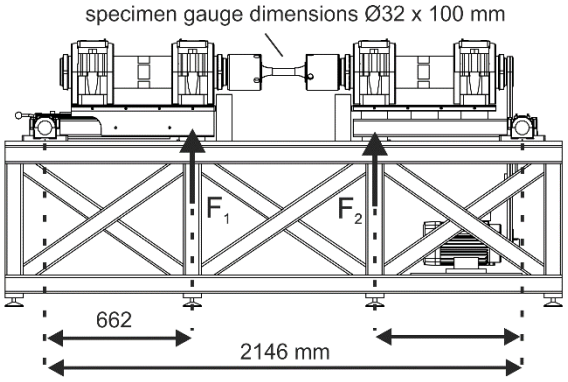

Figure 1. Schematic of the rotating bending fatigue testing machine, which is capable of generating a maximum stress amplitude of ~1000 MPa on a Ø32x100 (gauge dimensions) specimen with a loading frequency up to 48Hz.

Keywords: fatigue testing, rotating beam, rotating bending, size effect.