Bicycle Reliability Study

A bicycle manufacturer wishes to evaluate a new front fork design. The bicycle industry is highly competitive and the profit per bicycle is small so costs must be minimized. At the same time the bicycle must be safe for the consumer. The front fork is in loaded in bending and the magnitude of the force depends on the mass of the rider and the terrain being ridden. Note that the bending force from gravity counteracts the bending force from impact.

Figure 1. Typical midrange cost bicycle

Figure 2 shows the failure mode of the fork. The design criteria, for this manufacturer, is that there should be a 50% probability of failure for an average rider after 10,000 hours of riding.

Figure 2. Bending failure of front fork

Loading History

Extensive field testing has been conducted by the manufacturer, an example is shown in Fig. 3. This loading history represents 1 hour of riding by a typical user. Fatigue analysis has shown that the fatigue damage produced by this loading history is equivalent to a single loading cycle with a stress amplitude of 200 MPa for this fork design.

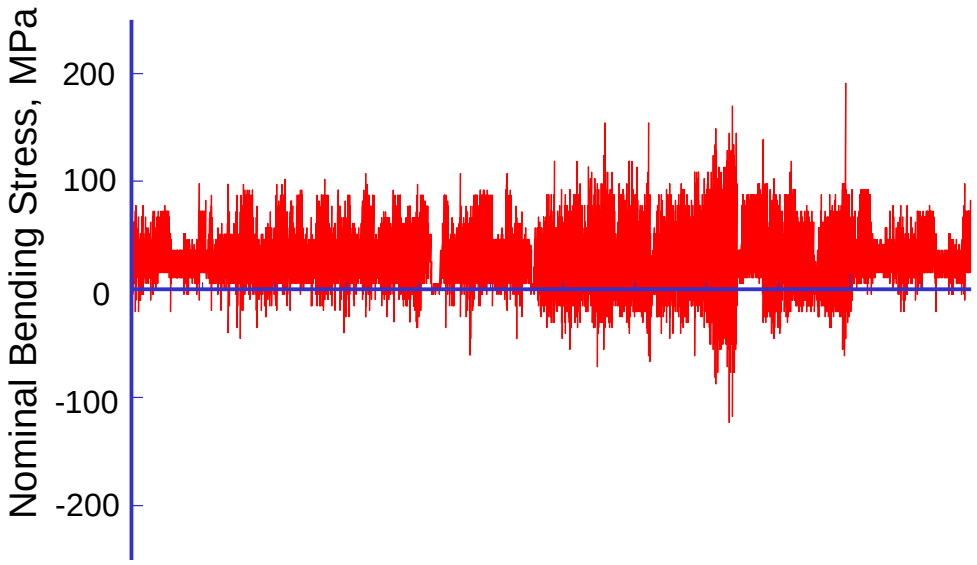

Figure 3. Front fork bending stress

Fatigue Testing

Bending fatigue tests have been performed on the front fork with the results shown in Fig. 3.

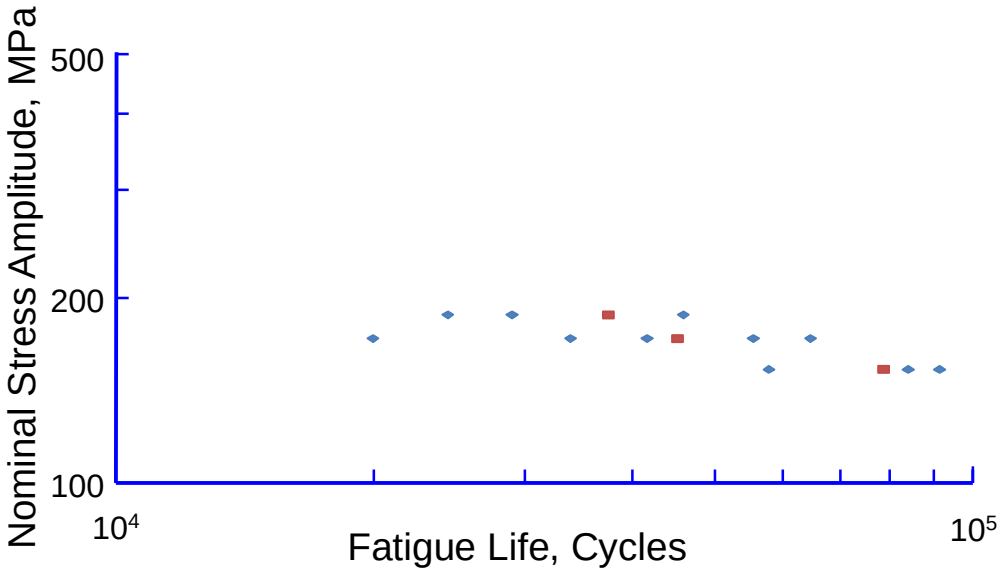

Figure 4. Fatigue test results

Fatigue Analysis

The blue symbols in Fig. 4 represent the fatigue tests. The stress concentration factor for the fork is unknown. But an appropriate value can be determined from a fatigue analysis of the test data to back calculate an appropriate value of K_t or K_f. Red symbols in Fig. 4 represent a K_f of 1.7 computed from a strain-life analysis. Normalized 1015 steel is used to manufacture the fork. The computed fatigue life for 200 MPa is 26,000.

Summary

Analysis and testing shows that the fork design meets the design requirements of a 50% probability of failure in 10,000 cycles or hours.

Calculation Exercises / Discussion

1. Considering typical variability in loads, material and manufacturing, what is the risk of a failure in 1000 hours?
2. What is the most important variable controlling the fatigue life?
3. Is the risk level reasonable?