

# Racing bicycle dynamics and the cyclist's comfort evaluated through outdoor field testing

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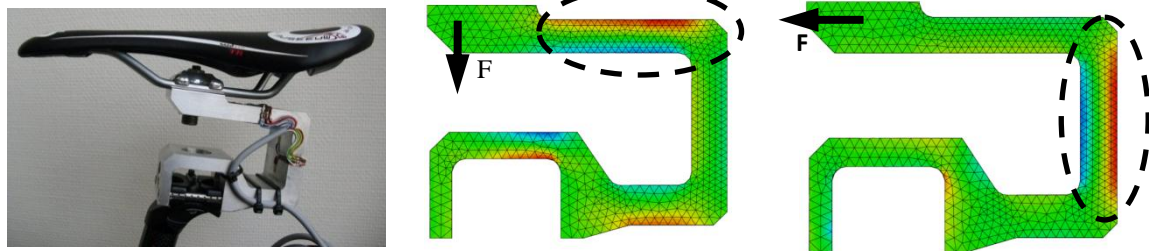
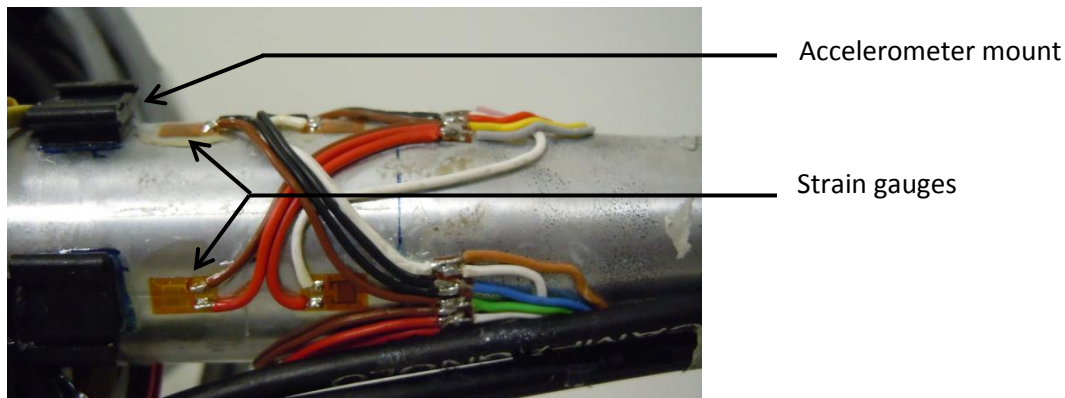
Both professional and amateur cyclists profit from technological improvements made in the design process of racing bicycles. These advantages are mostly found in weight reduction and stiffness increase of the bicycle frame. But besides these technological improvements, attention should be paid also to the vibrational comfort of the cyclist. The effect of superimposed vibration to any sports activity has proved to be detrimental for the sportsman. That is why bicycle designers come up with the question whether or not vibrational comfort for the cyclist can be quantified, and how it eventually can be improved. Vibrational comfort is widely found in automotive industries, whole-body and hand-arm vibration standards such as ISO2631, BS6841 and ISO5349 give information on how to measure and analyze vibration data. These standards measure the acceleration level at the contact points between man and vibrating machine, cf. cyclist and bicycle. The vibration dose value (VDV) is a measure of the comfort level when random vibration patterns occur. A high VDV implies severe comfort.

$$VDV = \left[ \int_{t=0}^{t=T} a^4(t) dt \right]^{1/4} [ms^{-1.75}]$$

Besides these acceleration based methods, the method of the average absorbed power  $P_{Abs}$  (AAP) puts forward both the contact force  $F(t)$  and the contact velocity  $v(t)$  as comfort evaluation criteria. The absorbed power is the energy dissipated in the human body due to internal vibration. The absorbed power is defined as:

$$\overline{P_{Abs}} = \frac{1}{T} \int_0^T F(t) \cdot v(t) dt$$

Based on this theory, a racing bicycle is instrumented with sensors measuring acceleration, force, and velocity at the contact points near the handlebar and the saddle. Real time data acquisition and data storage enables for outdoor field testing. Acceleration is measured with IEPE 100mV/g accelerometers. Velocity is then obtained by integrating the acceleration signal. The concept of measuring force at both contact points is based on the bending strain a cantilever beam is subject to when a load is applied. The figures below shows how the handlebar and the seat insert are instrumented for force measurements.



Field tests are performed with an MF5 hybrid flax-carbon composite racing bicycle. Test rides at a 180m long cobblestones road give a VDV value of  $7.2\text{ms}^{-1.75}$  and  $2.9\text{ms}^{-1.75}$  at the handlebar and at the saddle respectively. Data from the same test ride gives an absorbed power value of 21.4W. This value is the sum of 10.6W AAP at the handlebar and 10.8W AAP at the saddle. When riding a rough surface, some cyclists implement comfort improving cycling techniques. Not clamping the handlebar that hard as they should normally do and lifting themselves out of the saddle are common techniques. Here comes up the advantage of the AAP method, both comfort improving techniques are found in a reduced AAP value. The VDV method indicates for the same test cases an even worse comfort feeling.

These initial tests have shown that the instrumentation of the bicycle is successful and future work can give more results on how comfort is related to e.g. tyre pressure, cycling position, bicycle frame material, frame geometry, road pavement, etc.

#### Captions

- Figuur1 Instrumented handlebar for acceleration -and force measurement
- Figuur2 Insert below saddle, instrumented with strain gauges
- Figuur3 FE analysis of saddle insert, bending stress due to vertical force F
- Figuur4 FE analysis of saddle insert, bending stress due to horizontal force F