Experiment VS. Simulation of Bolts During Recoil

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What do rockets, a Formula One car, a roller coaster and a sneeze have in common? G-forces. A sneeze can result in 3G, and the highest recorded g-force of a roller coaster is 12G. What about a red dot sight mounted on a pistol and experiences recoil? That's at least 400G equivalent to $3928 m/s^2$*. For every second, the velocity changes by a staggering* $14140 km/h$*.*

Bolts in structures have to be able to withstand these forces, preferably by a large margin. To avoid having to conduct tests on every bolt that is to be used, is it possible to create a reliable simulation instead? This degree project deep dives into creating a test method to measure strain in bolts during high recoils. Simulations that mimic the test are then done to compare the results. This will contribute to a better understanding of design choices when bolts are exposed to recoils and further development of strain measurements and simulations.

The test methods were successful but unfortunately the resulting simulations showed that they are not reliable. However, it does not mean the end of the investigation of finding a good enough simulation method.

The test methods were developed by first 3D-modeling a test fixture, followed by simulating the fixtures to see if they can withstand the tests and to lastly perform the actual tests. An initial test was done to see that the equipment used for measuring the strain, called strain gauges, works as intended. A strain gauge works as an electrical resistor: when stretched, they increase resistance; when compressed, resistance decreases. These gauges provide an electrical signal from which the strain can be read. Tests were done on both conventional gauges, that can be glued to flat surfaces, but also on gauges that can be glued to the inside of holes. With a large enough bolt, a hole can be drilled into the shaft through the bolt head and a strain gauge can be built into it. When stretching the bolt, the gauge will stretch with it. After this, a similar method was followed to then conduct the tests of bolts in a shock machine.

When simulating a system, bolts are often removed but they are still a very important piece of the puzzle. This project investigates three different ways of simulating a bolt. Each model is increasingly more detailed, where the first model is represented by a single line with end conditions and the last is to have the complete model of the bolt (excluding the threads). The more details, the longer the time it takes to simulate, but it may also give the most realistic result. Even though the end result was not to rely on the simulations, the best result was achieved when using the most detailed model. This marks the end of this project but there is more to be discovered in future work.