Fracture toughness testing of the GEN40 aluminum single-axis knee joint

The date of the experiment: August 16, 2011

In this paper we discuss the fracture toughness test results for our newly developed single-axis knee joint.

In the joint currently in use the axle is attached to the body (bottom part), and the relative movement is achieved with a bronze insert in the top part. In contrast, the new joint contains bearings in the bottom part, which creates a more advantageous load configuration. The assembled joints can be seen in Figure 1.

Figure 1.

Fracture toughness testing with three setups was carried out. One trial was done for each configuration. The experiments were performed on a reconfigured Instron tensile testing machine for metallic parts. The tubes, attached on both sides to the knee were placed in fixtures, while the joint itself was pressed with the clamp part of the load cell.

In the first run the front of the front of the knee joint was facing upwards, as seen in Figure 2.

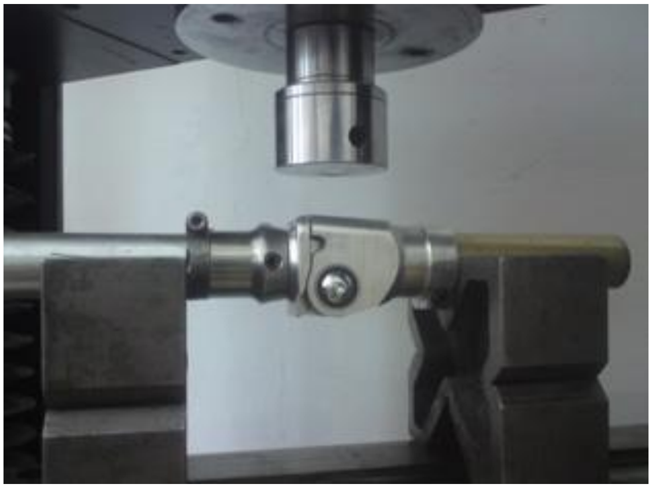


Figure 2. The first configuration.

The acquired graph is shown in Figure 3. The graph is to be read from right to left.

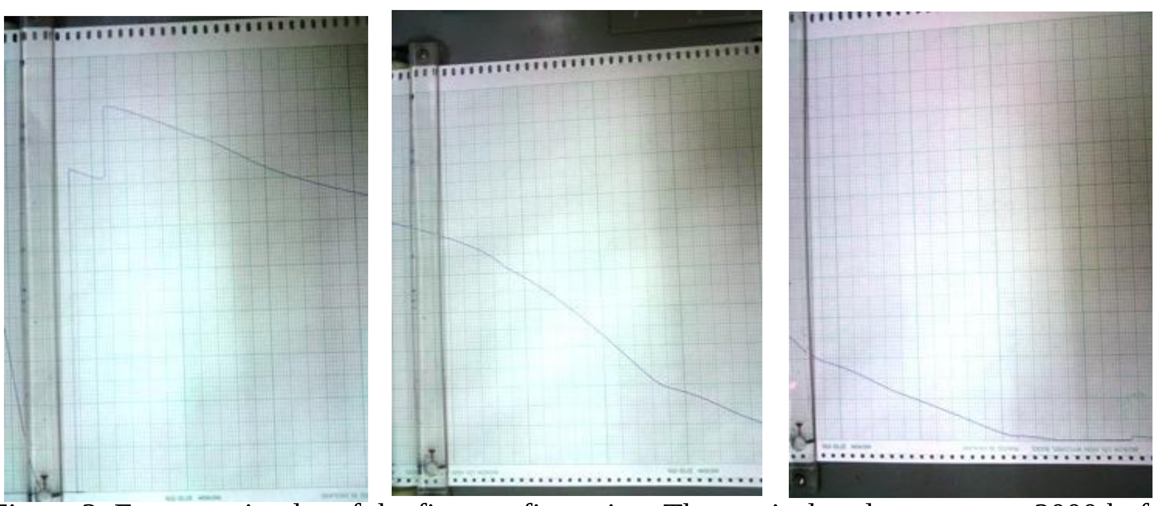
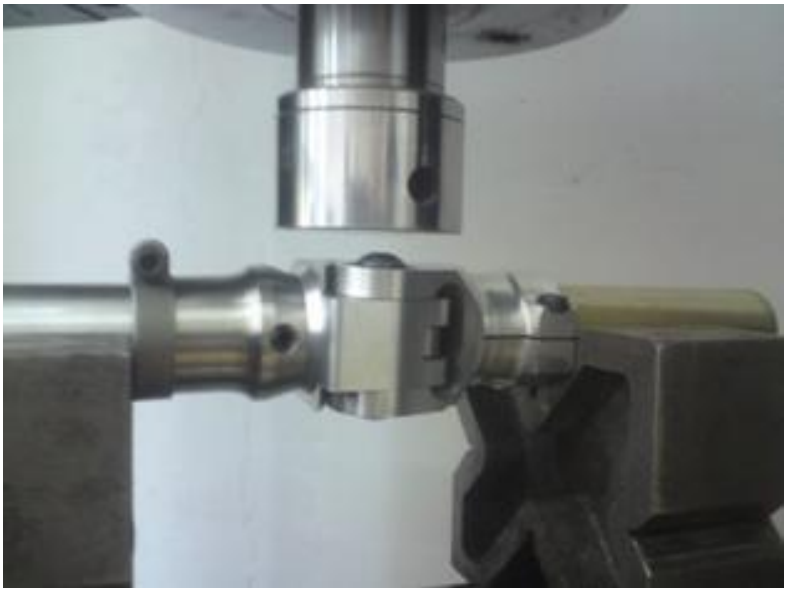


Figure 3. Force-strain plot of the first configuration. The vertical scale represents 2000 kgf.

The first deformation occurred at 1760 kgf at the connection of the adjustment core of the joint and the core support of the tube clam adapter. Shortly after this the load was removed. The joint (i.e. lock mechanism and rotation) was still properly functioning at the end of the run.

In the second run the side of the joint was facing the load cell (Figure 4a), providing lateral load. The graph is shown in Figure 4b.



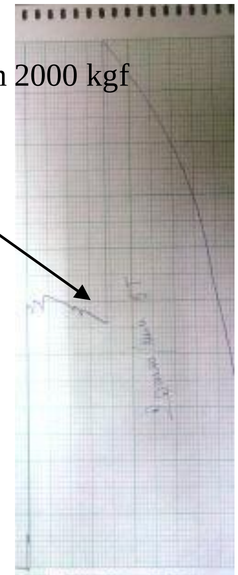
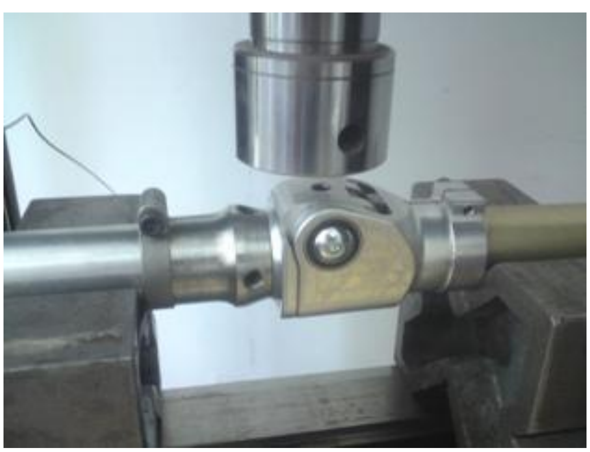


Figure 4. a. The second setup, b. Force-strain plot of the second configuration.

At first the 2000 kgf vertical scale was used, but the upper limit was reached so a switch was made to 5000 kgf. This shift is represented by the large step in the graph. The first deformation was observed at 2420 kgf at the adjustment core. At 2560 kfg both the bearing housing (the “ears” of the joint) and the bearing itself broke.

In the third configuration the back of the joint was facing the load cell (Figure 5a). With this setup the lock mechanism was targeted.



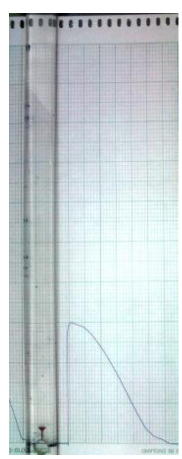


Figure 5. a. The third configuration. b. Force-strain plot of the third configuration. The vertical scale represents 2000 kgf.

At 600 kgf the pin in the lock mechanism failed due to the shear stress. It should be noted that the new joint contains a 5 mm diameter pin instead of the 4 mm pin in the old model. This is a 56% increase in cross section area which explains the increased shear strength.

We conclude that the new aluminum knee joint can withstand the various loads that occur during regular use.

We would like to thank László Sándor for performing the experiments, and the Plasmaterm SA for providing the Instron machine.

Ludovic Kántor, mech. eng.
General Manager
Elitex Prodexim SRL