Friction-coefficient between the Ti6Al4V loading pole and the 316LN steel shims of the HL-LHC 11 T magnets

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Friction in the HL-LCH Magnet System

Although superconducting magnets are primarily static systems, in particular large devices contain numerous surfaces that are prone to relative sliding, and thus their friction behavior must be controlled.

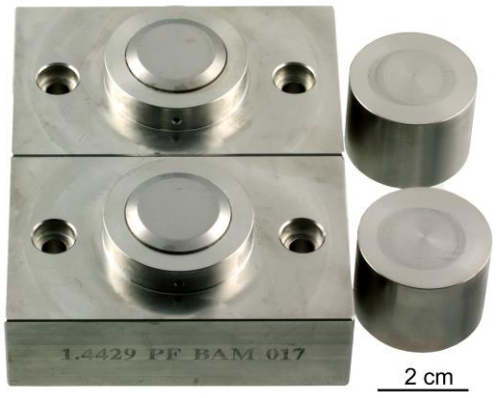
In the Large Hadron Collider High Luminosity upgrade (HL-LHC) project, some of the NbTi main dipole magnets will be replaced by 11 T Nb_3Sn magnets. The 11 T coils are mechanically loaded through a removable Ti6Al4V pole wedge, which is tangential sliding against 316LN stainless steel shims. Therefore, the friction behavior between wedge and shims influences the azimuthal coil stress and must be determined under conditions as close as possible to the real situation in the magnet

Results of Model Friction Tests

At room temperature in air Ti6Al4V shows smooth and stable sliding against 316LN with a friction coefficient of ~0.4. The transition between static and dynamic friction is also smooth and continuous.

At 4.2 K the pure metal-metal contact shows a strong stick-slip effect. Beside a disturbance of the geometry, the frictional heat created by such events is one potential origin of quenches in superconducting systems.

Application of the solid lubricant MoS_2 (spray) lowers the friction coefficient to about 0.08. A distinct static friction peak was observed, which is possibly minimized by an optimized coating method.



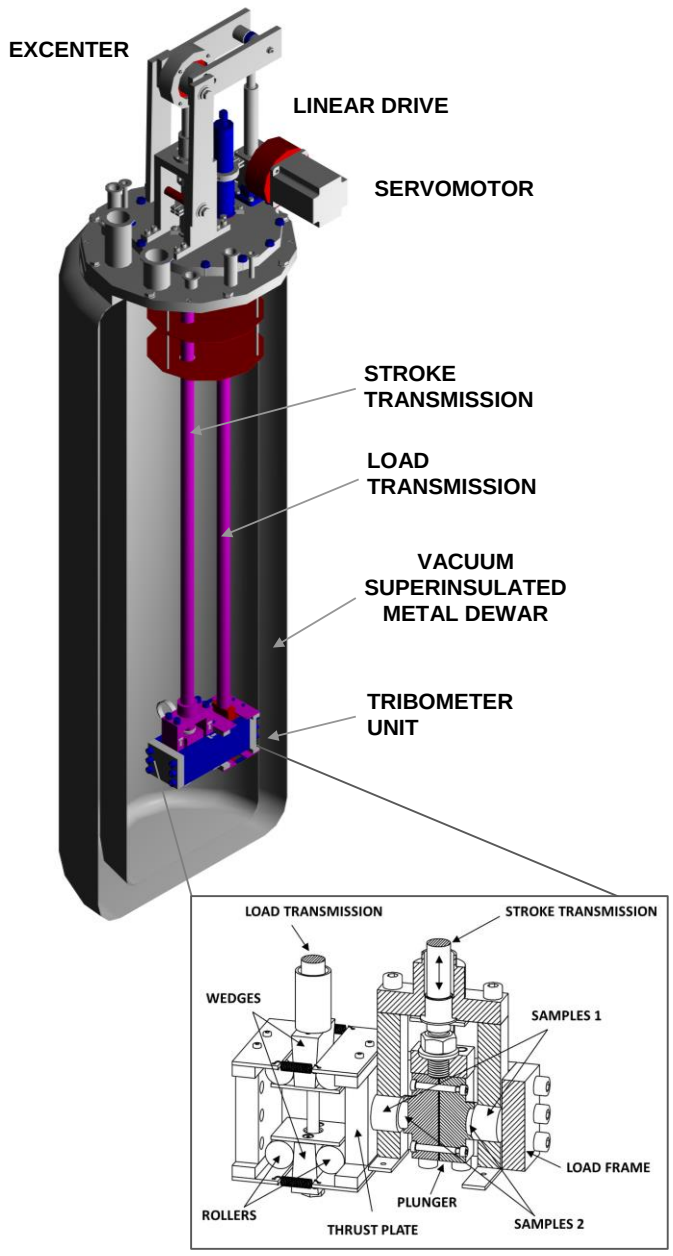
Test Specimen: Ti6Al4V pads in sample holders and 316LN cylinders

Sample Configuration:

body 1: steel 314LN cylinder
diameter: 30 mm
body 2: Ti6Al4V pad
diameter: 23 mm

Test Parameters:

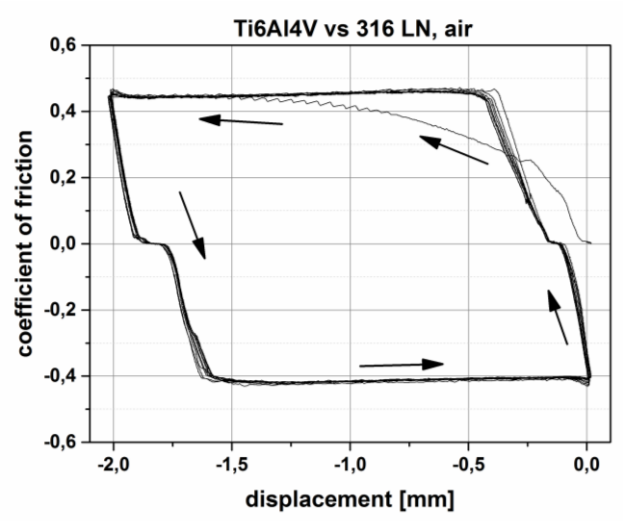
reciprocating sliding
stroke: 2 mm
sliding velocity: 0,1 mm/s
load: 25 kN (contact pressure 100 MPa)
test duration: 10 friction cycles
environment: liquid helium, air
temperature: 4.2 K; ~ 23°C



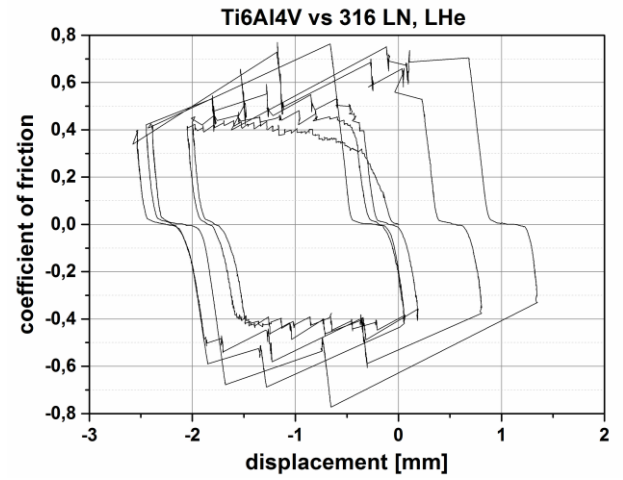
Cryostat with tribometer insert for reciprocating friction tests in liquid helium at loads up to 150 kN

Results

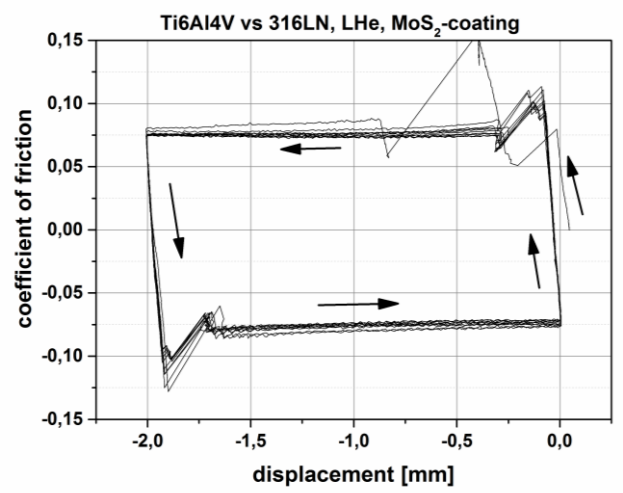
Friction coefficient vs displacement



Room temperature, air:
Smooth sliding without static friction peaks and stick-slip



4.2 K, liquid helium:
Strong stick-slip effect after the first friction cycle



4.2 K, liquid helium, solid lubricant MoS_2:
Smooth and stable sliding but distinct static friction peak

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