Experiment Number 18

What effect do organic friction modifiers have on a DLC on steel simply lubricated contact, in reciprocating sliding?

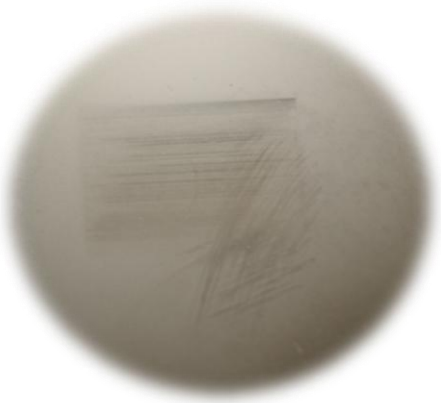
Test Conditions

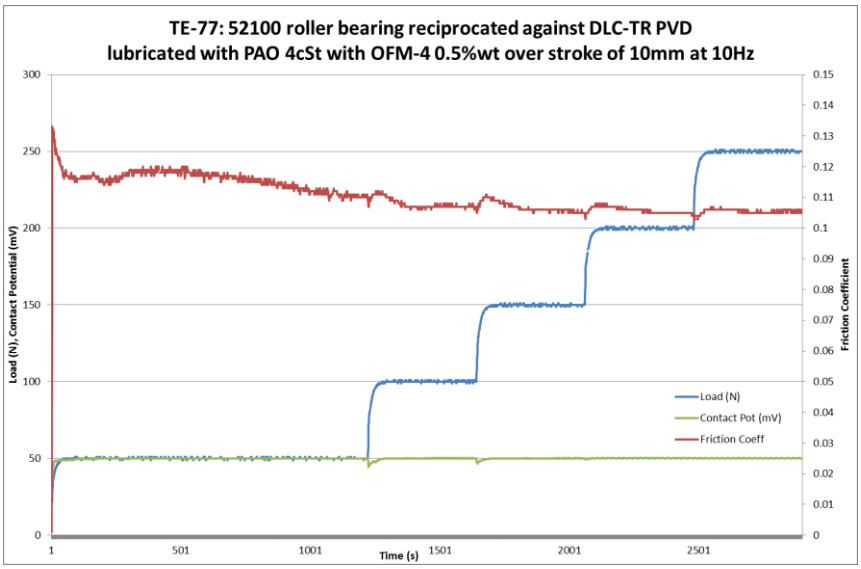
Stroke:	~12 mm	
Frequency:	10 Hz	
Moving Specimen:	6 mm diameter x 10 mm wide line contact	
	52100 steel bearing roller	
Fixed Specimen:	DLC-TR PVD	(nominally good)
	DLC-IBAD	(nominally bad)
Lubricant:	PAO (4 cSt at 100°C)	
Friction Modifier:	Organic friction modifier: straight chain polyamidoalcohol at 0.5 wt %	
Temperature:	25°C	
Load:	Ramped from 50 N to 250 N in 50 N steps	
Mean Contact Pressure:	Substrate:	Ramped from 190MPa to 430MPa
	DLC Samples:	Ramped from 250MPa to 560MPa
Duration:	50 minutes	
Data:	Load	
	Friction	
	Contact Potential	

Summary of Results

- DLC-TR PVD has a higher friction coefficient compared to IBAD as in the non-additive case (Experiment 1).
- DLC-TR PVD has a lower wear rate than IBAD.
- The friction modifier reduced the friction force for both DLC coatings.
- DLC-TR PVD has a velocity independent friction response compared with IBAD, which has a velocity dependent response.
- In the case of the IBAD coating, the friction force took a similar form to the non-additive case, but with a reduced magnitude.
- The friction modifier affects the form of the DLC-TR PVD high speed friction trace, suggesting a substantial change in lubrication mechanism.

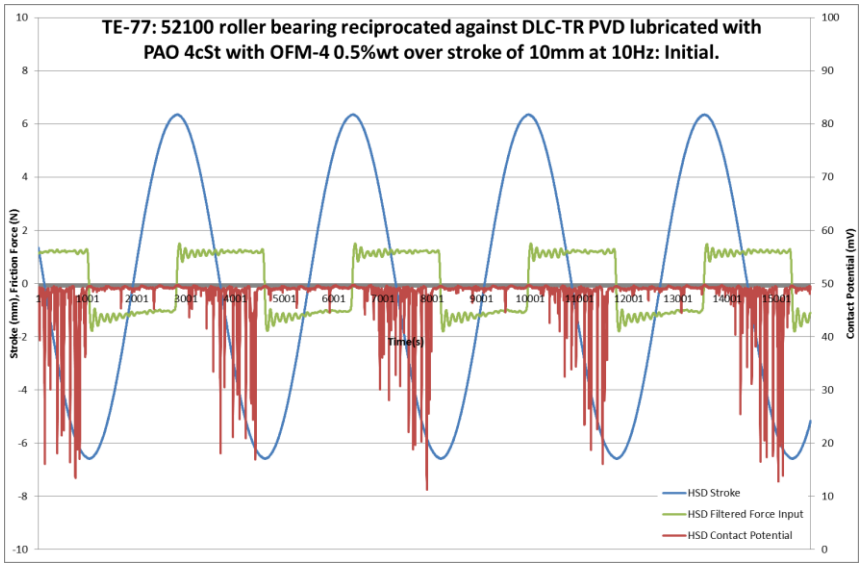
DLC-TR PVD - (nominally good)

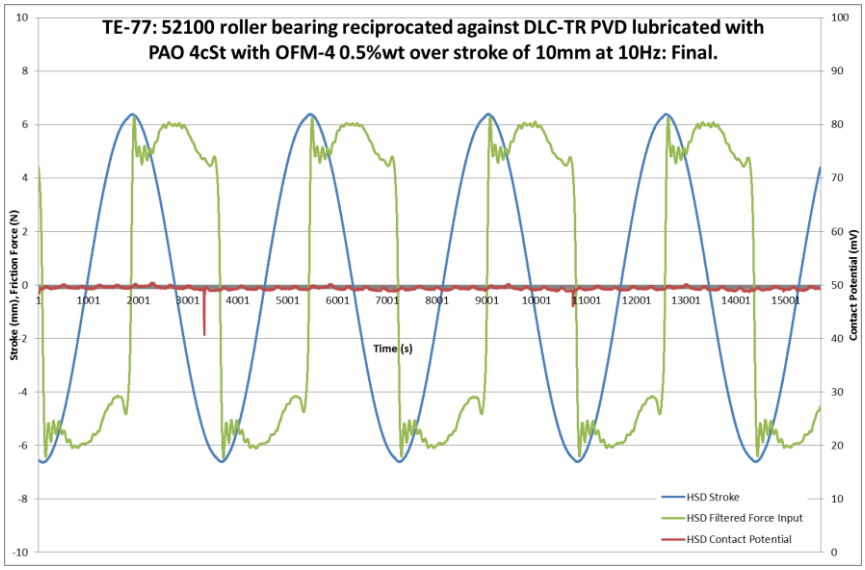




Low Speed Data

- The addition of the friction modifier results in the friction force exhibiting slight running-in behaviour at each load step. The friction force decreases throughout the test.
- Mean friction coefficient approximately 0.10.
- The contact potential remains saturated throughout the test with very minor drops observed at each load step.





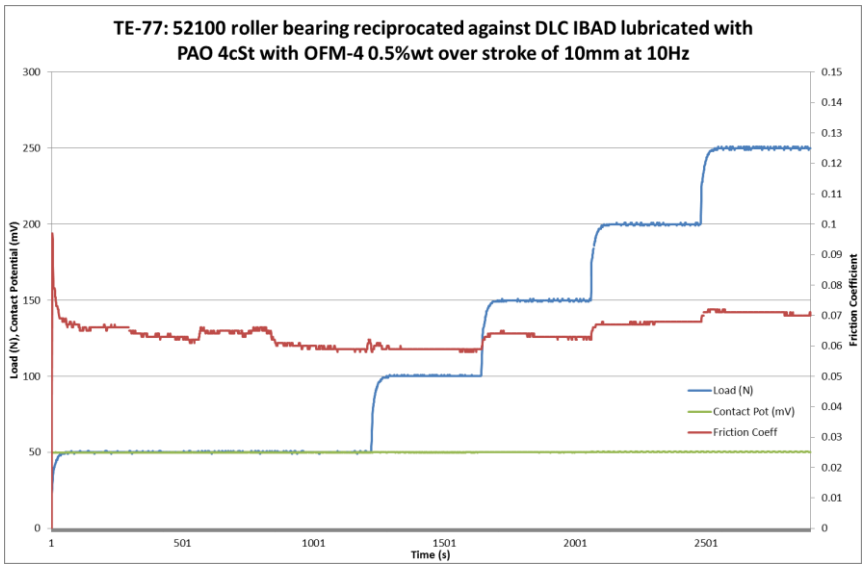
High Speed Data

- Similar to the non-additive case[1], the friction force is a square wave with "plucking" resonance.
- Likewise, contact potential break down is also observed, but with greater intensity. It should be noted that in both cases this effect is only seen in one sliding direction and in each case it is in the same direction.
- At the end of the test the contact potential is saturated, unlike the velocity dependant shape seen in the non-additive test.
- Of most interest is the intriguing shape of the friction force. During each stroke the friction force starts at about 5N then at a critical location/speed, increases with a small ramp time to 6N, and then decreases symmetrically about the stroke centre point.
- The maximum friction force during the stroke is ~6N as is the case for the non-additive test.
- Visual examination of the two tone wear scar was in keeping with the mid stroke change in friction force.
- "Plucking" spikes and resonance was observed on the leading edge of the signal, as in the non-additive test.

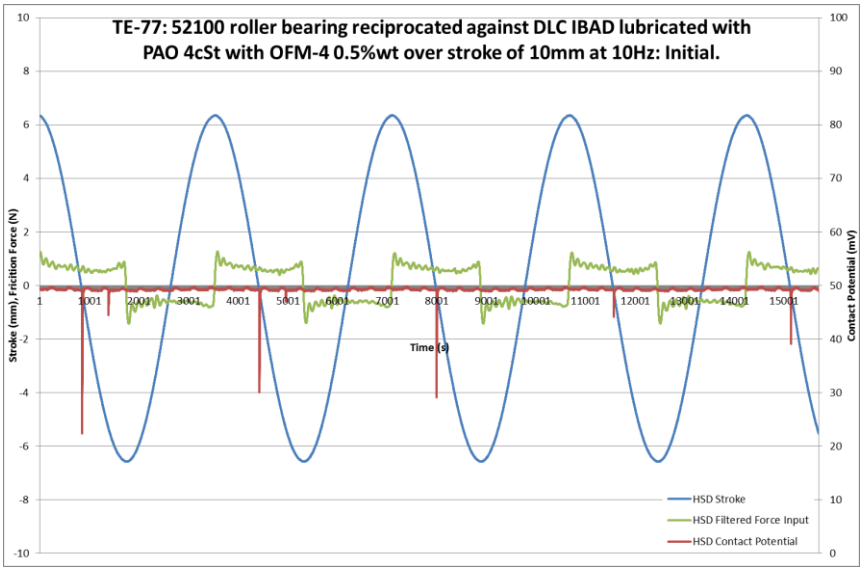
[1]See Experiment 1 for Non-additive case

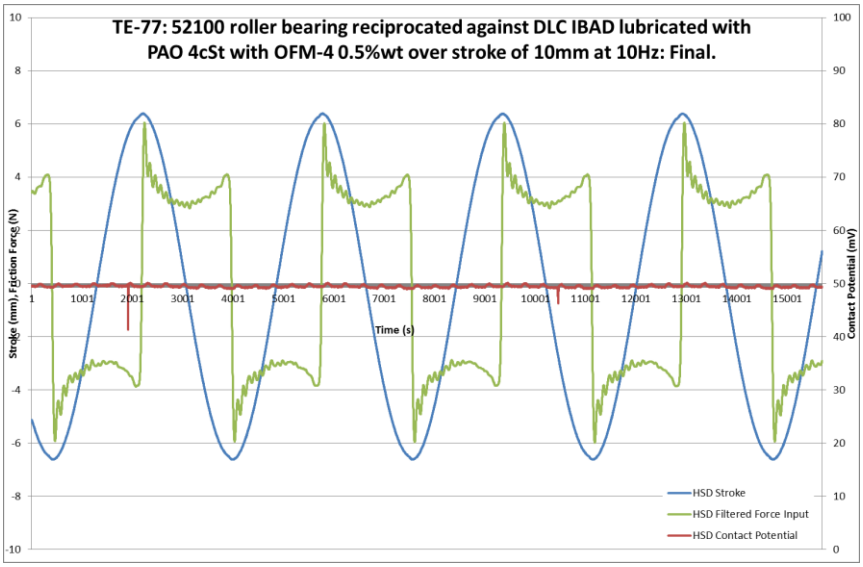
DLC-IBAD - (nominally bad)

Low Speed Data



- The friction modifier caused the friction force be reduced throughout the test.
- Running in only occurs at the beginning of the test and then increases slightly with each increasing load step. Midway through running in, a temporary increase in the friction force is observed; this correlated with high speed data at the time, which showed an increase in friction force in one stroke direction, halfway between the midpoint and reversal point of the stroke.
- The contact potential remains saturated throughout both tests.





- From the friction traces over the duration of the base and additive tests it is hypothesised that the increase in friction in the PAO-base test is caused by a 3rd body in the contact and the roughening of the surface caused as the third body is created from the surface of the DLC sample. This is thought not to occur in the friction modifier test as the additive prevents the asperity contact from causing significant wear by reducing the shear force.

High Speed Data

- The friction trace from the friction modifier test exhibits a similar velocity dependent reduction at the start and end of the test to the PAO-base test; however the magnitude of the trace is less. By the end of the test a friction spike of 8N is observed on the leading edge of the trace and the main body of the parabola occurs between 4 and 2N. This is a 30% reduction in friction force, which can be directly attributed to the friction modifier.
- Unlike the PAO-base test there is no breakdown of the contact potential by the end of the test.