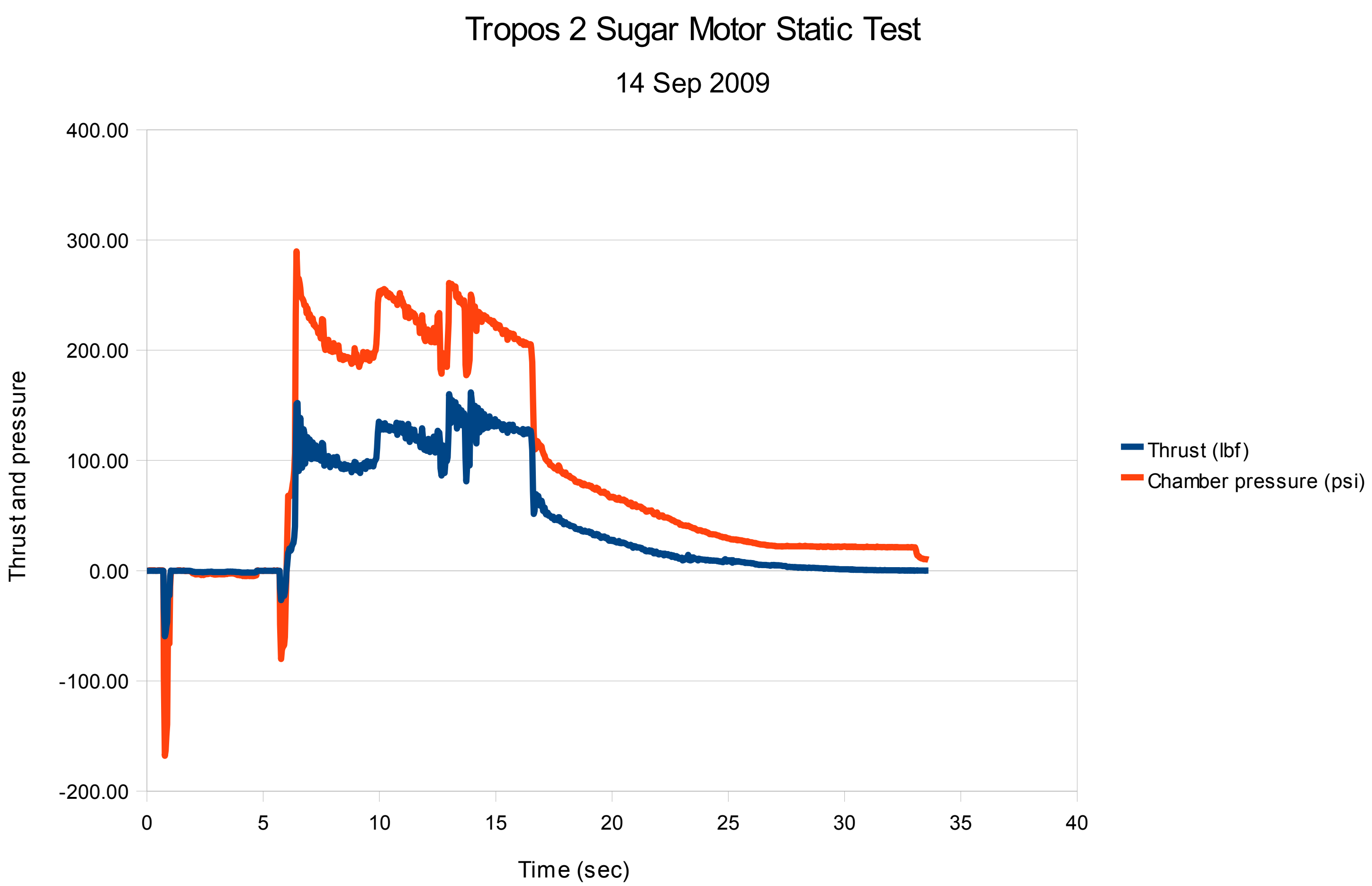
Static Firing Data and Discussion: Tropos 2 Sugar Motor 14 Sep 09

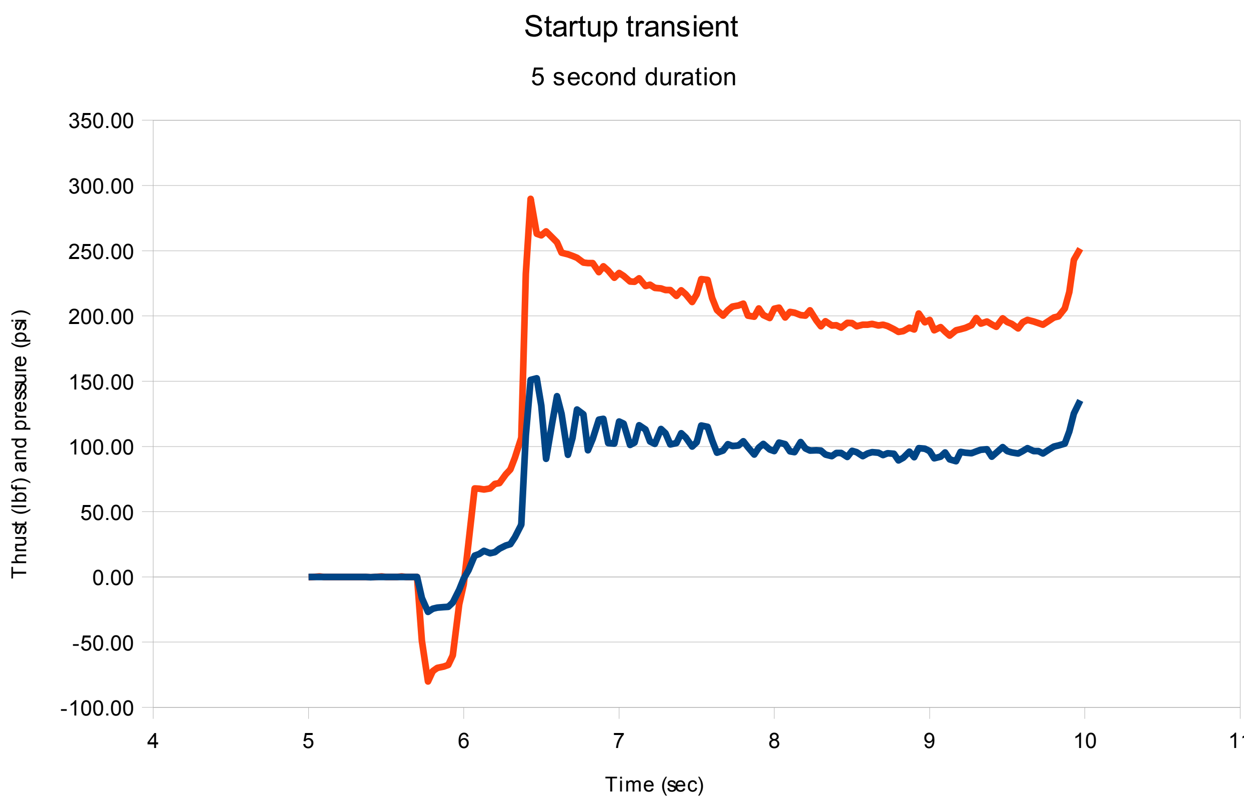
Test conditions: tank and motor on 1000-lb capacity "trapeze" test stand with Interface SM-500 500-lbf load cell and MSP-300 1000-psi pressure transducer. Smaller valve with "butterfly" handle was used for the main nitrous oxide valve. A new nozzle with no fiberglass overwrap was used. Otherwise, test configuration virtually unchanged from that used during static firing demonstration at the 4th IREC.

No video was taken of this burn. Synopsis: igniters worked well, motor ignited immediately after main valve was opened. Total burn duration (with significant thrust) was 11 seconds, but motor showed significant "surging" during the burn, with shock diamonds appearing and disappearing in the flow. Towards the end of the burn, sparks were ejected from the motor. There were no visible leaks in the nitrous plumbing or in the motor during the firing. Motor continued to burn with a slow flame after nitrous was exhausted. Flame was put out with a spray bottle. The aft end of the motor was very hot and continued to flash water that was sprayed on it for several minutes after the burn.



The negative spikes on the plot correspond to the igniter firing and valve opening. The igniters, valve, and data system were all run from the same battery, and presumably the negative spikes were from momentary drops in voltage during igniter firing and valve opening.

The thrust data again showed a 4-5-Hz oscillation immediately after the motor ignited, and it damped out after about 1 second. Since a diffent test stand was used this time, it does not appear to be something mechanical with the thrust stand as was previously surmised. The cause of this oscillation is still unknown.



Postfire inspection showed that the motor forward end contained a large amount of charred ash in the forward mixing chamber. There was a hole in the center of the ash chunk presumably caused by the nitrous oxide flow. The injector had ash on its face but the holes were clear. One side of the motor appeared to have no fuel left, but we think this was due to molten fuel "slumping" after the burn. No metal appeared to be burned, so we believe the sparks were hot ash particles being ejected. The injector plate O-rings were in good condition and showed no sign of blowby. The nozzle retainer O-rings were completely burned in place, and it was difficult to tell if there was blowby or not (the inside of the motor case and the nozzle retainer were black, but this could be from the charred O-rings. The screws were not damaged). We believe that the nozzle tranferred much more heat to the motor casing since it had no fiberglass overwrap, and this is what burned up the O-rings.

The final mass of the motor (with nozzle and retaining ring but no injector plate) was 1950 g (4 lbs 5 oz). This resulted in an approximate fuel residual of 570 g (590 g expected). The nozzle throat had eroded from 0.666" diameter before the firing to 0.75" after.

Since the only major change from the previous static firing was the use of the smaller valve with the butterfly handle, the theory is that the port in this valve was too small, causing excessive pressure drop either in the valve itself or due to the changes in fluid path diameter. It is possible that some of the nitrous oxide flashed to vapor and some froze into solid. Solid chunks may have blocked the injector, reducing thrust, then been blown clear, increasing thrust again, then more chunks were formed and the process repeated until the liquid nitrous was exhausted.