3nd X-Bearing Friction Test with Experimental Results
ufodoctor3, April 19th, 2019

1. Introduction to the "Rattle Problem"

Many forum colleagues complain the x-bearing of the JGaurora5 3D printer.
With perfect cleaning of the entry ports of the x-bearing and lubrication of the x-rods the printing works fine, else the the stepper motor cannot complete the steps and will rattle. This causes an x-offset for the upper printing layers of many mm.

2. Investigations with reduced x-stepper motor current

With an auxiliary friction test device (Fig.1), connected between the base unit and the tower the x-friction can be investigated at reduced torque to find out, where the x-rod needs to be polished or cleaned!

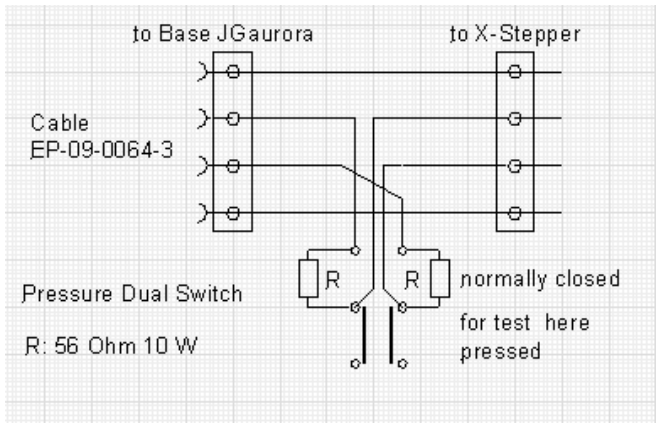

Fig. 1: First Friction tester device

Parameter	Signal mV	Diff to Zero mV	Current A	Max Force N
Zero, no Supply	2433			
+ Pulse	2594	161	0.403	16
- Pulse	2247	-186	-0.465	
Test with Serial Resistor 56 Ohm in both coils				
+ Pulse	2583	150	0.375	9
- Pulse	2251	-182	-0.455	

Power in Resistor I^2 x R
P 11.5934 W

Force Sensor: Mechanical spring scale 20 N
Current Sensor:
Sparkfun Digi-Key 1568-1882-ND, 5 A
400mV/1A (DC up to 80 kHz)

Fig. 2: Test with Current Sensor Sparkfun

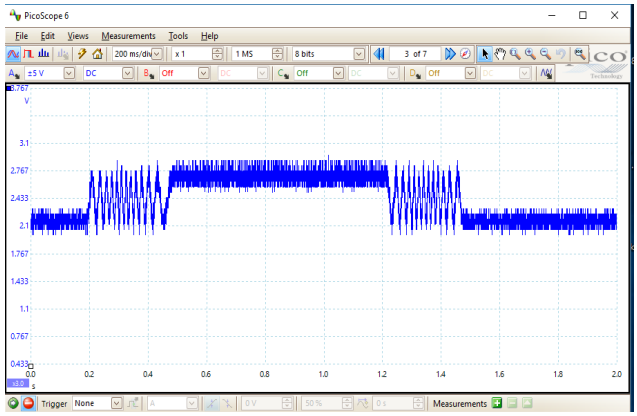

Fig. 3: Current into a coil pair for 12 x-steps steps of total 10 mm, 400mV/1A

1. Measured Parameters

Name	Value	Units	Description
m	0.2	kg	Mass of the extruder
s	0.01	m	Step with x-move =10 mm
t	0.22	sec	Duration for 12 step
Fmax	16	N	Maximum Force when blocked
I	0.5	A	Current
R1	1	N	Friction x-bearing
R2	3	N	Friction x-system (idle, power off)

2. Calculations

				Formula
Vavg	0.045	m/sec	Average speed	s/t
Vpeak	0.091		Peak Speed with 12 steps 50%	Vavg*2
a	0.41	m/sec^2	Acceleration	Vpeak/t
F	0.81	N	Force required for x-motion	m*9.81*a

3. Conclusion

Fmin	3.8	N	Minimum demanded force	R2+F
SF	4.2		Safety Factor	Fmax/Fmin

Fig. 4: Approximate Calculations
Safety factor 4.2 for Print Steps 45 mm/sec

Comment: The maximum force of 16 N when blocked is about 3.8 above the minimal demanded moving force of 4.2 N at printing speed of 45 mm/sec, but a travel speed of 100 mm/sec is very close to the force limit of the stepper motor!

3. First Test Setup

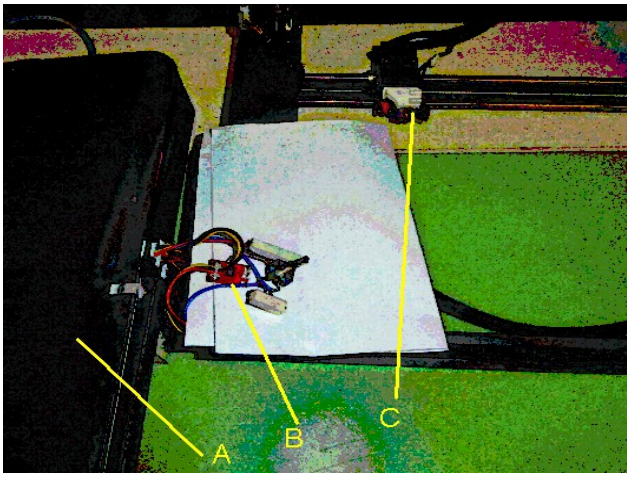

Fig. 5: First Test Setup
Base Unit and Tower disassembled

A: Base Unit JGaurora
B: First Friction Tester with Current Monitor by Sparkfun
C: Moving Extruder on x-rod

With the reduced x-stepper torque (by the test device Fig.1) the non-perfect areas of the x-rod can be located by a rattle noise.

These x-areas need to be polished!

Comment:
Starting this friction tester before every printing and hoping not to observe “rattle”, the x-system is ready for operation.

4. Improved Test Setup

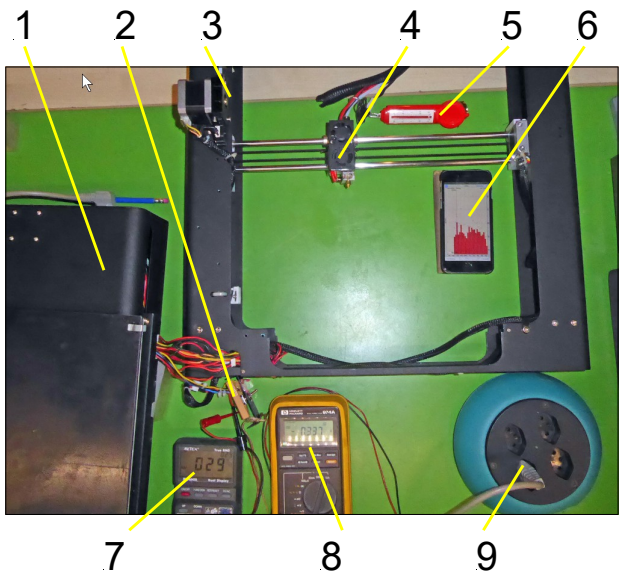

Fig. 6: Improved Test Setup for x-bearing friction investigations
1: Base Unit JGaurora
2: x-Friction Tester, Switch 2x68 Ohm serial
3: Tower JGaurora
4: Extruder
5: Mechanical Force Sensor 0 to 20 N
6: IPhone with RTA App Sound Recording
7: Temperature monitoring of the Serial 68 Ohm Resistors. The temperature increases by 50 Deg Celsius within 7 minutes at multiple x-move commands.
8: Current into the x-Stepper Motor
9: Power Source 230 V AC

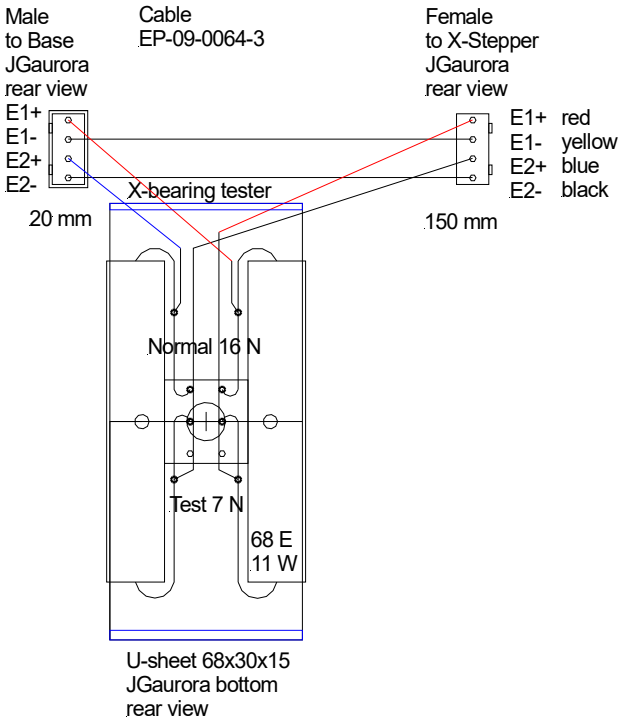

Fig. 7: 2nd X-Bearing Friction Tester
1: U-sheet JGaurora, 2: Original Bore D3.2,
3: 2-Pol Switch, 4: Alu Heat Sink 10x10,
5: Resistor 68 Ohm 11 W

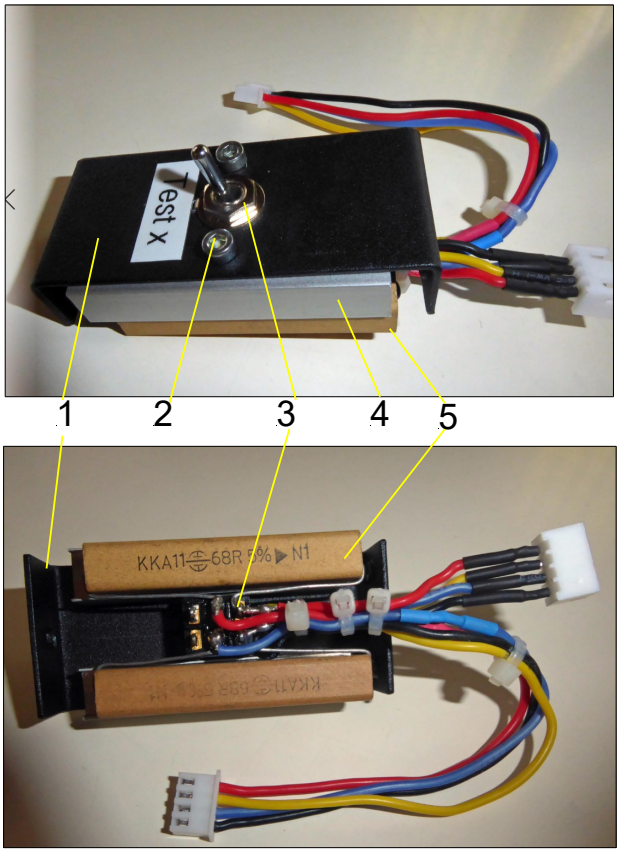

Fig. 8: X-Bearing Friction Tester mounted into the JGaurora tower

Attention:
In the test mode the resistors will heat up to 73 Deg Celsius by multiple x-shift command of 10 mm during a 7 minute measuring period.

Without x-shift commands the current into the stepper seems to be stopped after one Minute by the JGaurora software, no more heating!

5. Experimental Results

5.1. Friction by DIRT on the entry of the x-bearing

The main source of x-bearing friction could be the DIRT at the entry ports of the upper long x-bearing!

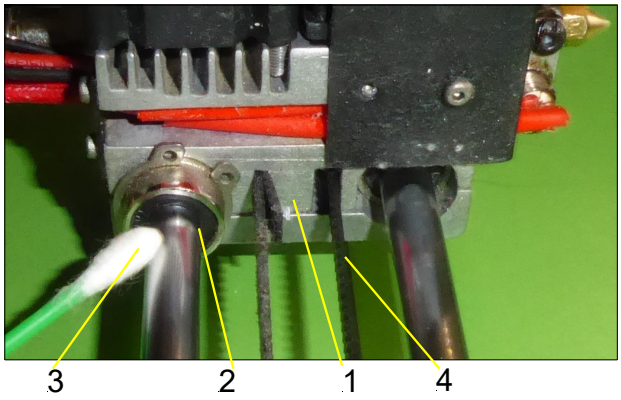

Fig. 9: Cleaning the entry ports of the upper x-bearing

1. Extruder
2: DIRT at the entrance of the x-bearing port
3: Cotton wool stick, moisten by Isopropanol
4: Toothed belt, perhaps with dirt, too

Please examine this entrance port with magnifying lens with adequate illumination!

Fig. 10: High Standard Wiper Ring
Kull-Laube AG, CH

This would be the best protection of the x-bearing against accumulated dirt on the rod.

However, the friction of these wiper rings are about 2 x 5 N, with and without lubrication, thus too much for the x-stepper motor of max 16 N force!

Comment:
Any additional friction at the x-bearing is counterproductive for a good operation of the JGaurora5 3D-Printer.

5.2. Sound generated by the x-stepper motor at multiple 10 mm x-steps

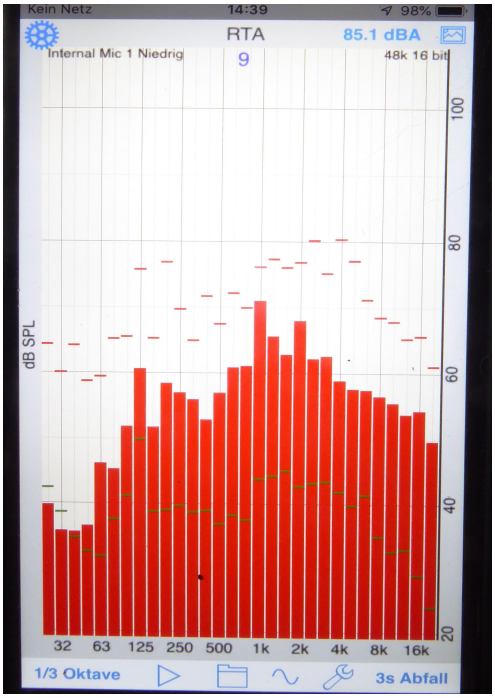

Fig. 11: Normal operation with 0.5 A
max 70 dB A at 1 kHz
Maximum blocking force: 16 N with loud rattle

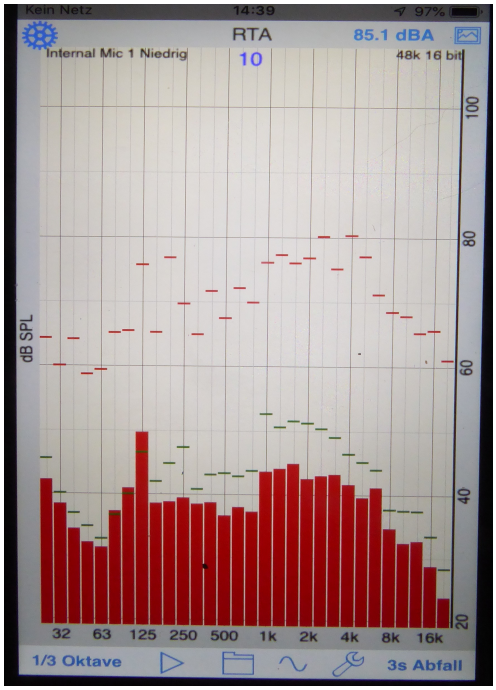

Fig. 12: X-Friction Test with 0.34 A
max 50 dB A at 125 Hz
Maximum blocking force: 8 N with loud rattle

Comment: in an former experiment we noticed a rattle noise already at reduced current! This was when the entry ports of the x-bearing were not cleaned perfectly and the stepper motor got problems to complete his steps neatly.

6: Discussion and Conclusion

- This friction tester provides a better understanding for the “Rattle Problem” of the x-System

- The original and the replacement x-bearings by AliExpress are suboptimal, but appropriate for this low cost 3D-Printer, but only with perfectly cleaned x-bearings ports and rods!

- A new replacement bearing, fresh from factory, shows a friction of about 0.5 N with some noise of the internal moving spheres. After lubrication the friction was below 0.2 N, with almost no noise by the spheres!

- The main advantage for replacing the x-bearing is the fact, that you apply a new CLEAN bearing on a CLEANED rod, which will operated for a short time nicely , as I hope!

Our advice: Clean the bearing entry ports and rods, hereon lubricate the rods and reduce the travel speed to not more than 50 mm/sec if you notice rattle noise.

Good luck!