

How to reduce the vibration of neutron choppers

Qing Zhang
CSNS chopper group

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中国科学院高能物理研究所
Institute of High Energy Physics
Chinese Academy of Sciences



Outline



- **Background**
- **Goals**
- **How**
- **Result**
- **Summary**



Background

- CSNS Chopper Group have developed 9 neutron choppers for the 3 day-one instruments.
- 2 T0 choppers and 7 disk choppers
- Installation and commissioning were completed by the end of 2017.



SANS



MR



GPPD

Background

■ Disk chopper

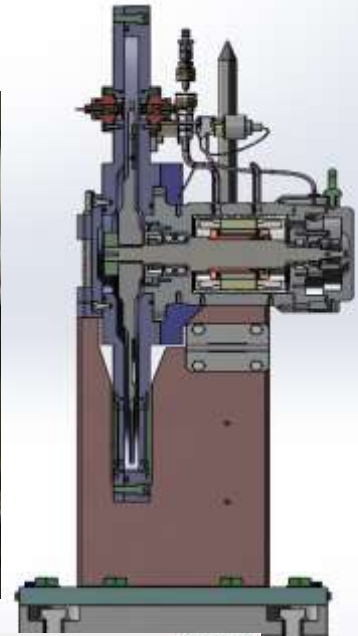
Rotation Speed: 25/50Hz

Structure: Cantilever, the bearing is only on one side of the rotor

Dynamic Balance: ISO 1940/1 G1.0

Vibration: 0.6mm/s@25Hz、
4.2mm/s@50Hz

Bearings: Deep Groove Ball Bearing +
Cylindrical Roller Bearing



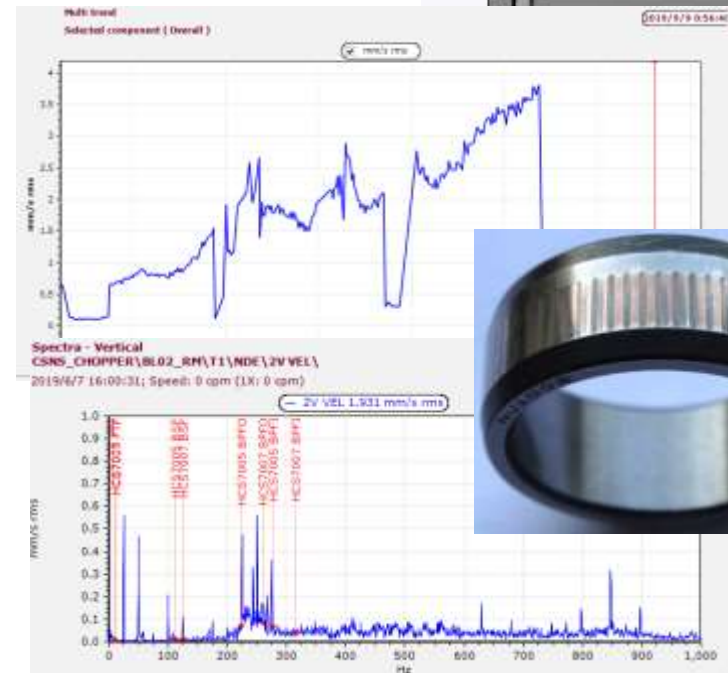
■ Problems during operation

Chopper ID T3 Disk for BL18

trend: 0.6mm/s~3.8mm/s(25Hz)
2017.12~2019.07

whys: Bearings damage-Problems
about the type and clearance of
the bearings

Consequences: Replace bearings once a year



Background

■ T0 chopper

Rotation Speed: 25Hz

Structure: Direct drive, located bearings on both sides of the rotor.

Dynamic Balance: ISO 1940/1 G2.5

Vibration: 0.12mm/s@25Hz、
6.7mm/s@50Hz

Bearings: Double-row self-aligning ball bearing + Deep groove ball bearing

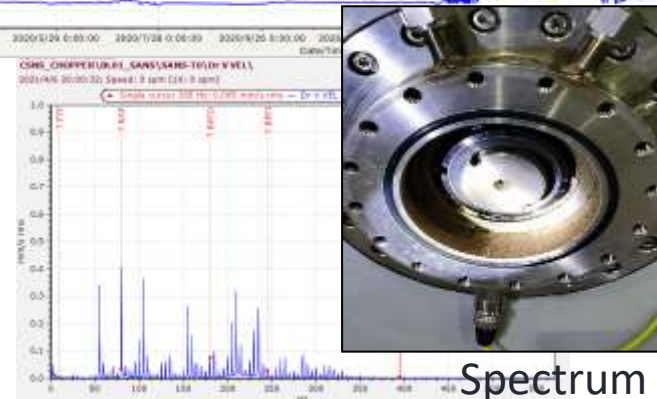
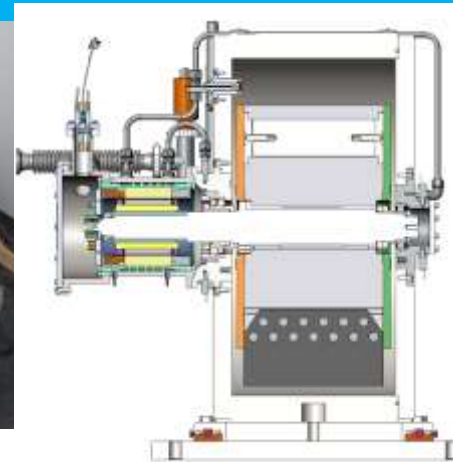
■ Operation

Chopper ID: T0 chopper for BL01

trend: 0.12mm/s~3.7 mm/s(25Hz)
2017.12~2021.03

whys: Bearings and Dynamic unbalance

Consequences: Cannot operate at 50Hz;
Maintenance intervals of 3 years



Spectrum graph

The expected goals

■ WHY

- ✓ Improve operational stability
- ✓ Extend component lifespan
- ✓ Ensure safety

■ The expected goals :

- ✓ 1. Disk chopper can operate at above 50Hz with lower vibration levels.
- ✓ 2. T0 chopper can operate smoothly and efficiently at 50Hz~100Hz.
- ✓ 3. All choppers : maintenance intervals is about 5~10 years.

How

- The essence of vibration: The combined effect of forces and stiffness

$$\overrightarrow{Vibration} \sim \frac{\overrightarrow{Force}}{\overrightarrow{Stiffness}}$$

- Measure

- ✓ Reduce force
- ✓ Improve stiffness

- Design

- Process

- Test

For design

■ Bearings

- ✓ Increasing the number of supported bearings on the shaft: 2 → 4
- ✓ Type: Angular Contact Ceramic ball bearing, 2-back-to-back arrangement (FAG X-life)

■ Shaft and rotor

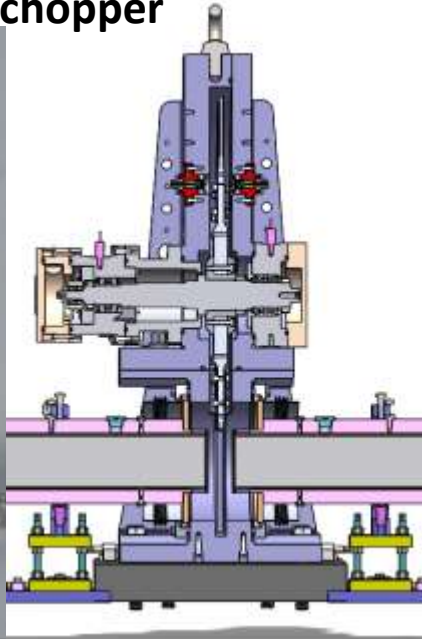
- ✓ Increase the diameter of the shaft appropriately
- ✓ Reduce the cantilever length
- ✓ Reduce mass of rotor

■ Housing

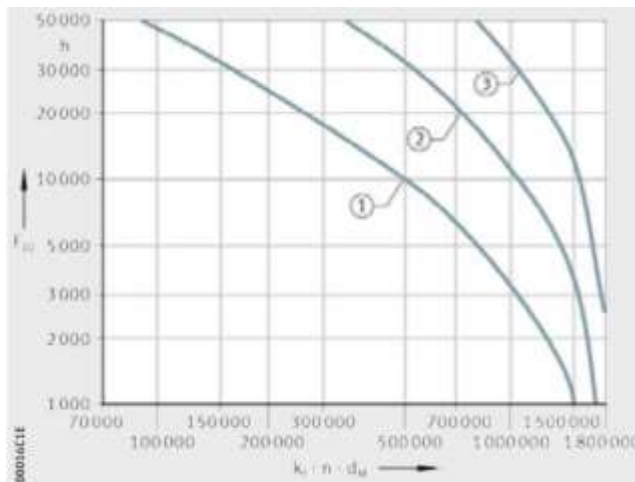
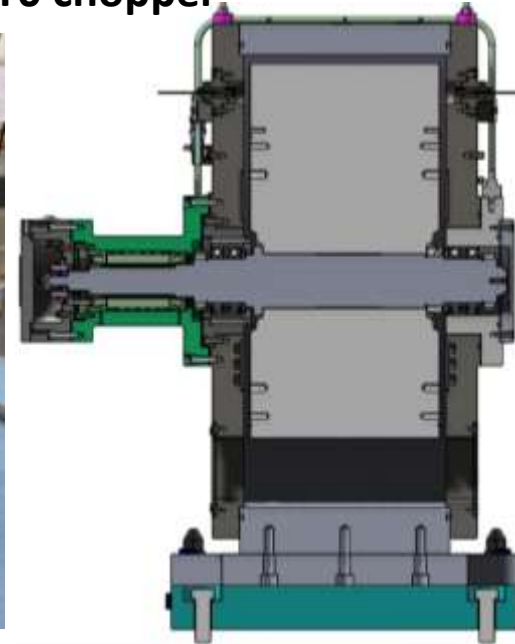
- ✓ Change the housing material to stainless steel
- ✓ Increase the stiffness of the lower body

New design

Disk chopper



T0 chopper

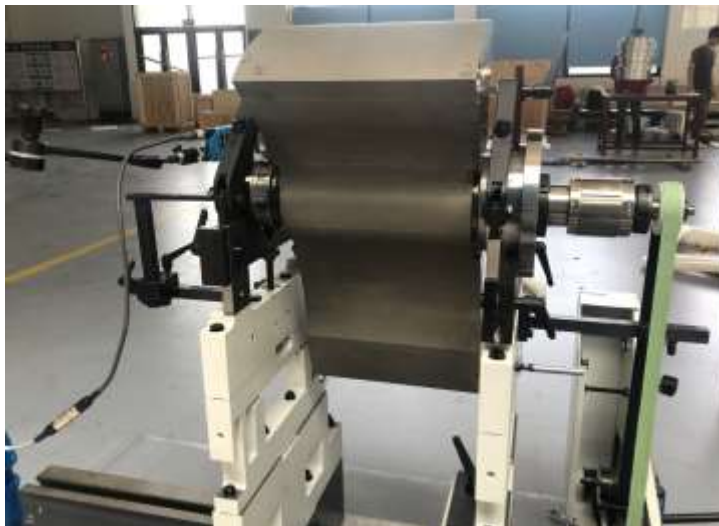


About lubrication

Under equivalent conditions, the lubricating grease lifespan of X-life bearings is approximately **10 times** longer than that of ordinary steel ball bearings.

For process

- Improve machining precision and ensure assembly quality.
- Control the clearance of the bearing within an appropriate range.
- Dynamic balancing: a. This involves mounting the rotating part on a balancing machine . b. The field dynamic balance by portable Dynamic Balancing Testing System



For test

- 1. Vibration testing before leaving the factory : detect vibration levels and potential bearing installation faults.
- 2. Connection rigidity: To avoid a soft foot.
- 3. Drive up, drive down, resonance testing, and motor current signature analysis were performed.
- 4. 3-month long-term operation test and monitor the vibration trend

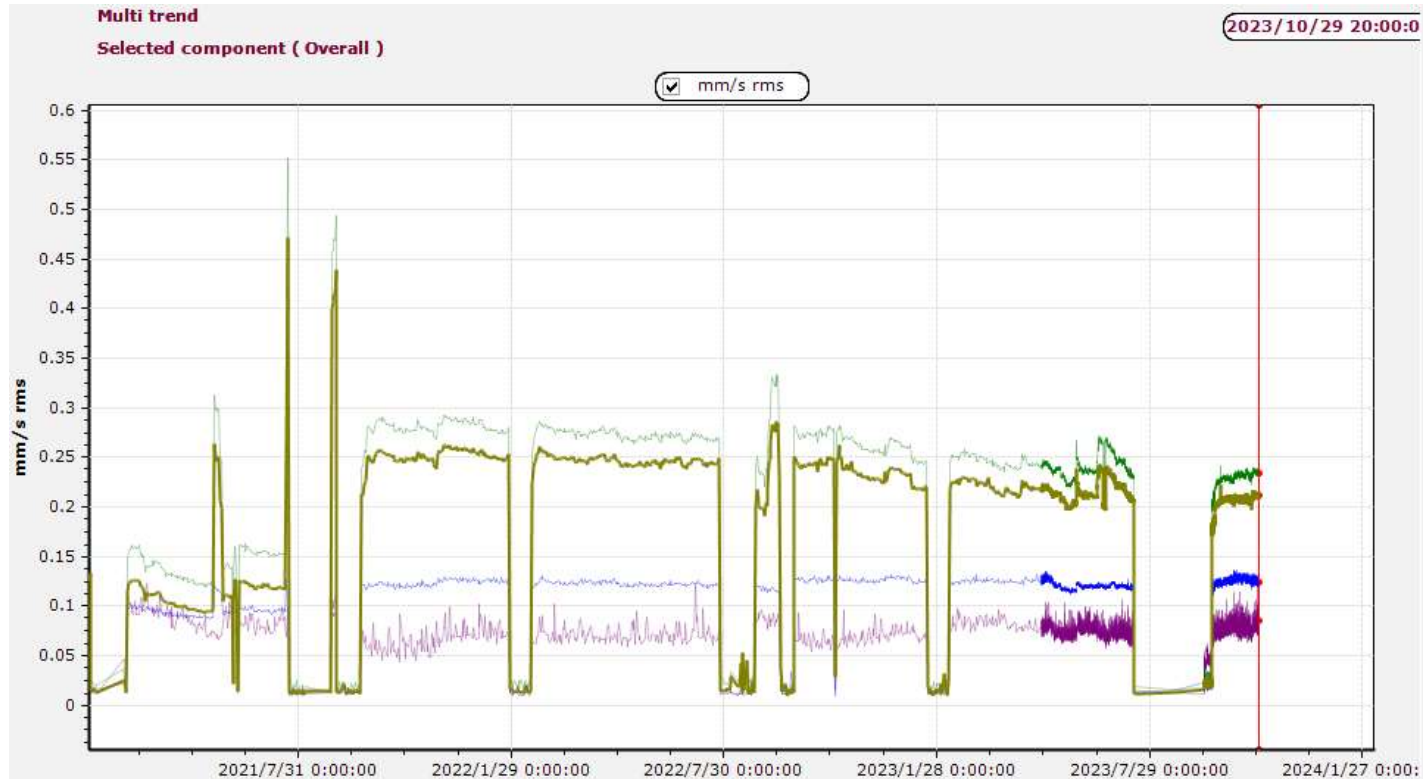


Result

Disk	Rotation Speed	25Hz/50Hz/100Hz
	Vibration	0.05mm/s @25Hz 0.045mm/s @50Hz 0.18mm/s @100Hz
	Trend	Stable, fluctuation less than 10% (2021~2023:15057h)
T0	Rotation Speed	25Hz/50Hz/100Hz
	Vibration	0.02mm/s @25Hz 0.06mm/s @50Hz 0.46mm/s @100Hz
	Trend	Stable, fluctuation less than 10% (2021~2023:15057h)

Result

■ Trend

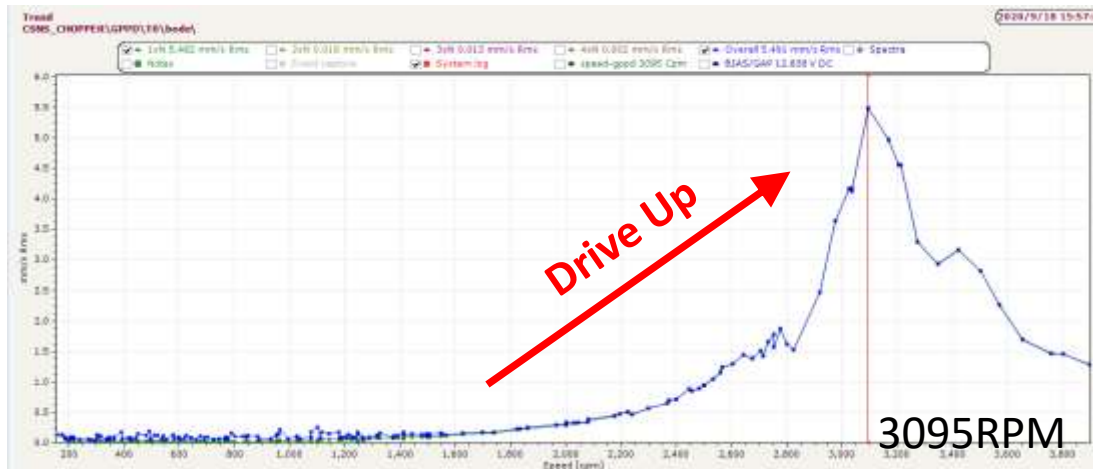


Time:2021.3~2023.10

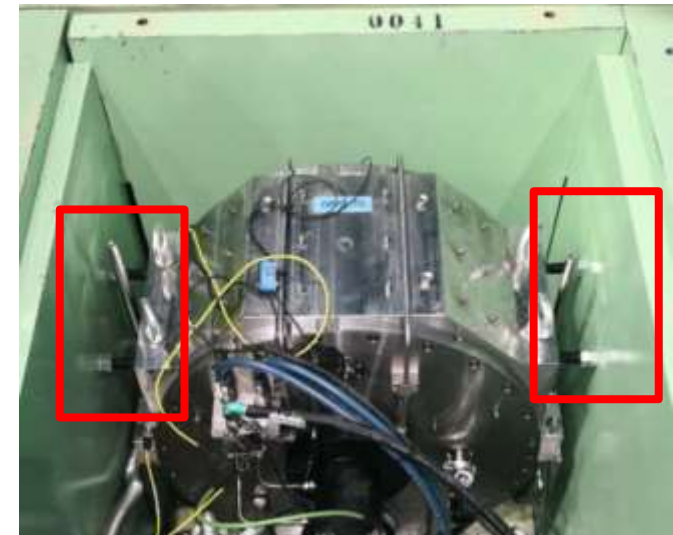
Trend chart of 4 vibration measurement points on a chopper

Unpredictable

- T0 chopper: run at 3000 RPM
- vibration values: 0.7mm/s @Factory testing→1.8mm/s@ On-site commissioning →5.1mm/s @ After installing the top shielding block
- The resonance range is at 3095 rpm



- A quick solution is to add damping.



5.1mm/s → 0.43mm/s@3000RPM

Summary

- Choosing suitable bearings and lubricating grease can extend the maintenance interval of the chopper.
- For high-speed choppers, field balancing is crucial.
- The rigidity of the shielding around the chopper affects its vibration.
- Current vibration levels are satisfactory for long term operation , with a stable trend.



Thank you

