Loaded double ball bar - LDBB

Contactless excitation and response system - CERS

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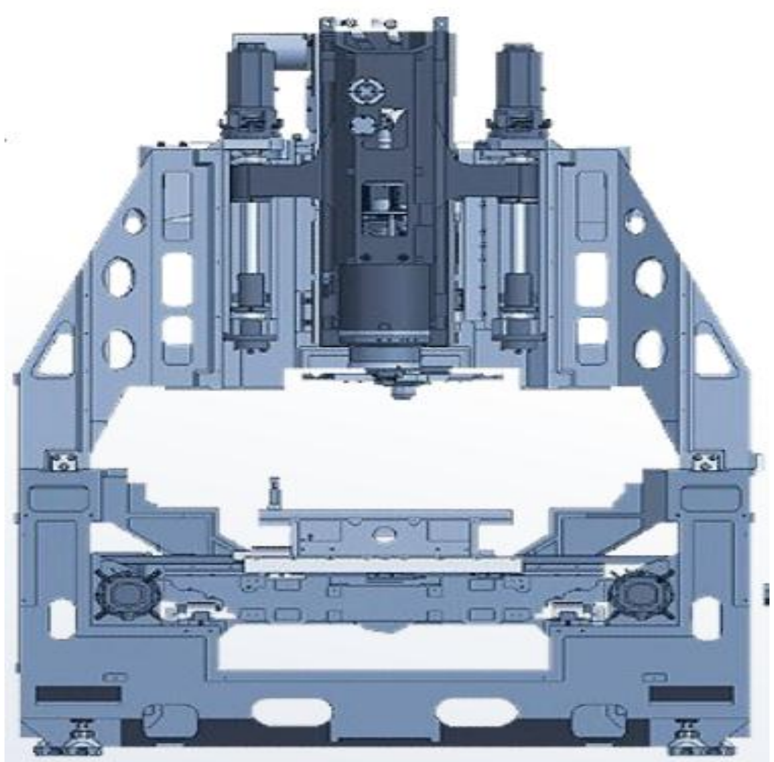
Agenda for presentation

1. Introduction to the research field
   - Research motivation
2. Loaded double ball bar (LDBB)
3. Contactless excitation and response system - CERS

Unlike most other types of mechanical systems, machine tool structures, due to high requirements on accuracy, are dimensioned with respect to static and dynamic deflection, and corresponding design criteria of stiffness must be applied.



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State of the art

Why characterization of machining system?

- Realistic evaluating of machine tool.
  - Comparing candidate machine tools
- Control and optimization of machining system.
  - Process, components, tools, fixtures
- Maintenance, lack of quick and robust methods
  - Need for practical and fast methods to evaluate a machine tool under loaded condition

- Virtual machining and feature based programming.
  - e.g. replacing M and G codes, STEP-NC.

Relevance

- New environmentally friendly and safe vehicles require light weight materials with higher strength and, as a consequence, tougher machining conditions and increased machining robustness.

- The very complex system of machine tool, fixture, cutting tools and the machined part is **almost impossible to model without complementary measurements** in and manufacturing experience collection from the real system.

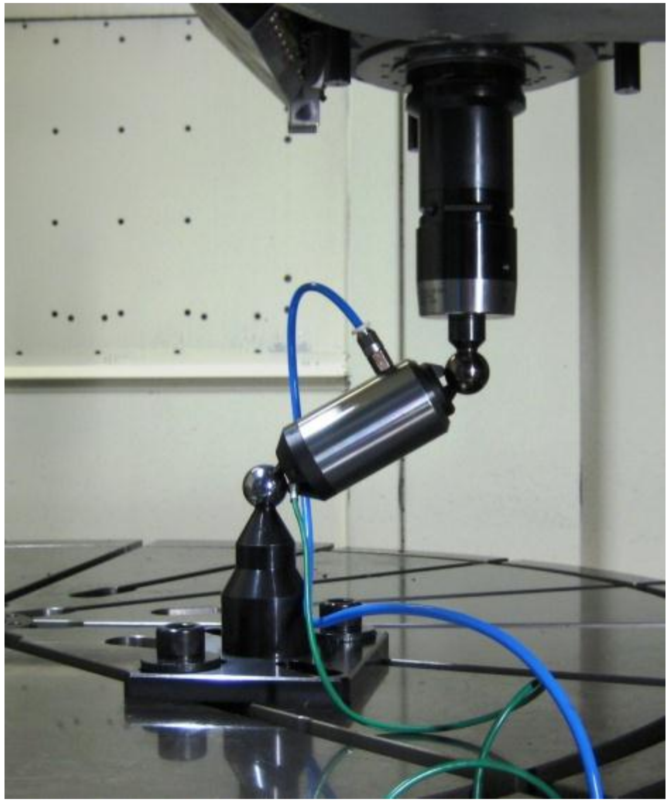
Production machines ⟷ Manufacturing of parts

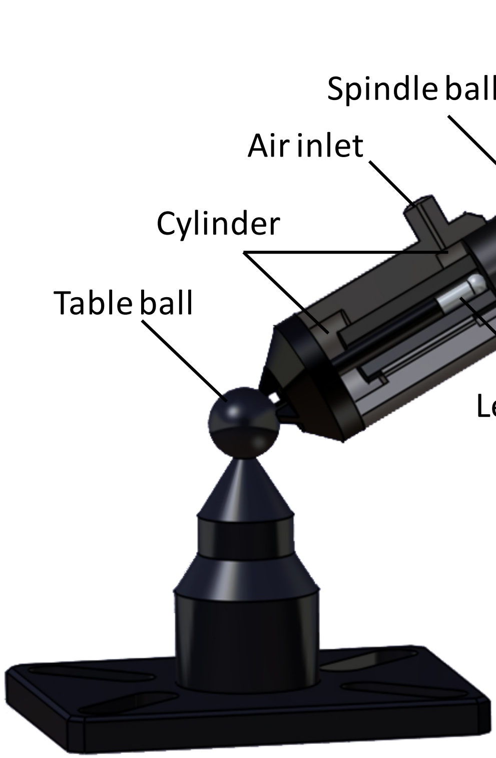
- Design
- Manufacturing
- Maintenance

- Quality
- Productivity
- Cost

Off-operational machining system

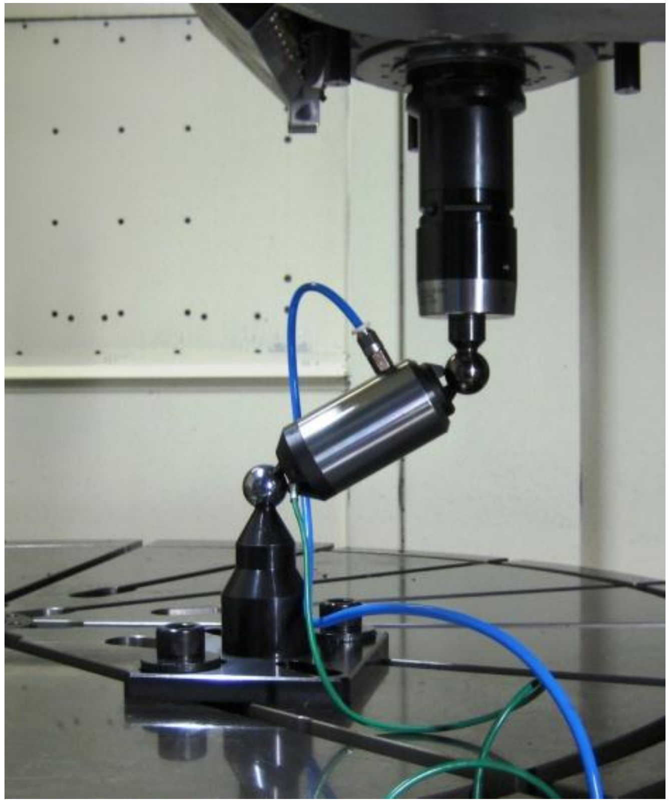
Loaded Double Ball Bar (LDBB) for static evaluation



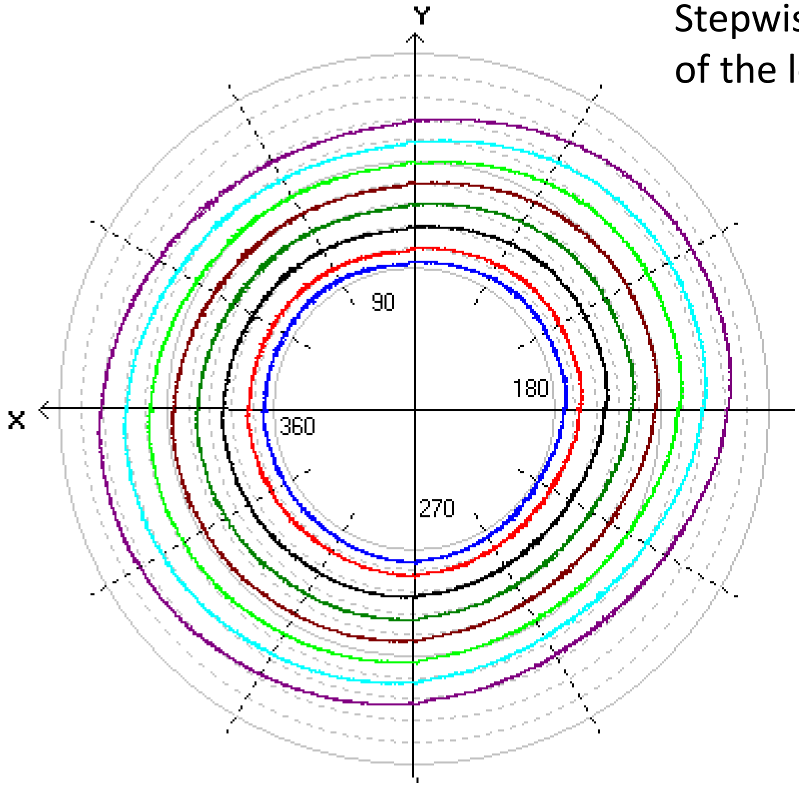


Off-operational machining system

Loaded Double Ball Bar (LDBB) for static evaluation



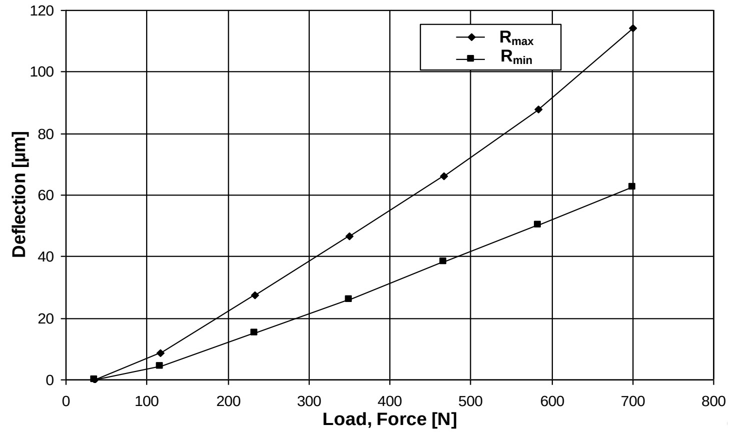
Displacement in X-Y plane

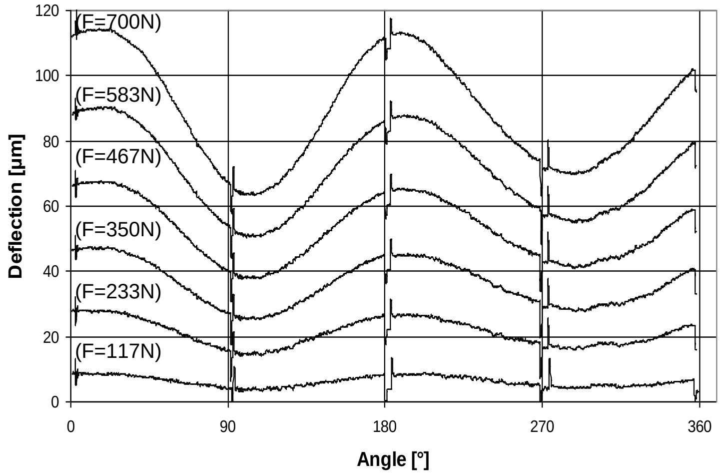


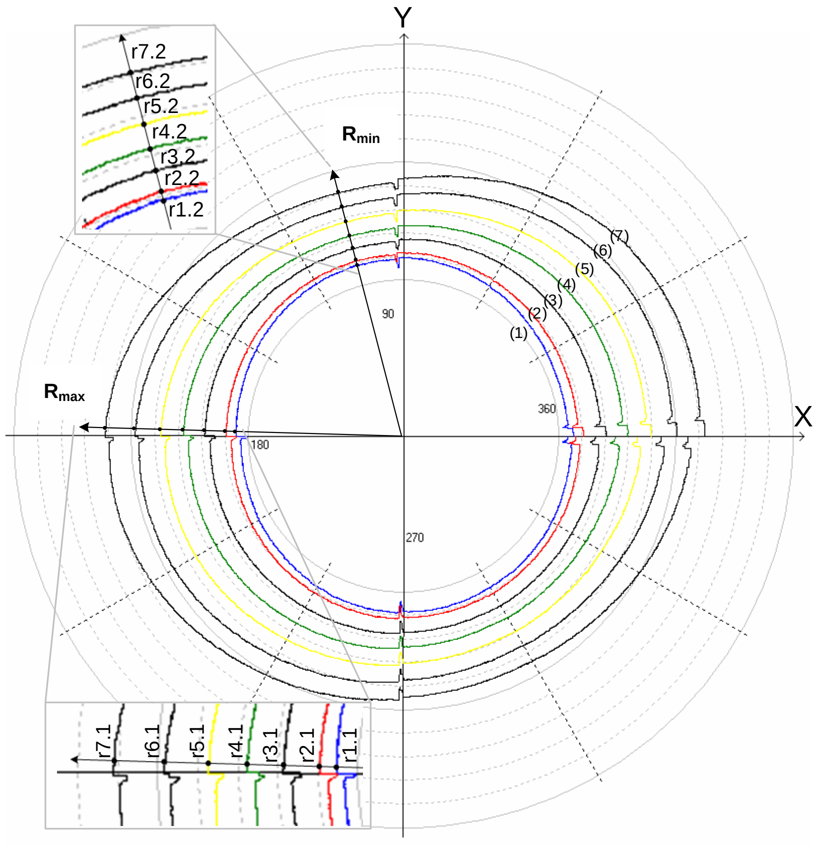
Stepwise increase of the load

Off-operational machining system

Loaded Double Ball Bar (LDBB) for static evaluation







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Off-operational machining system

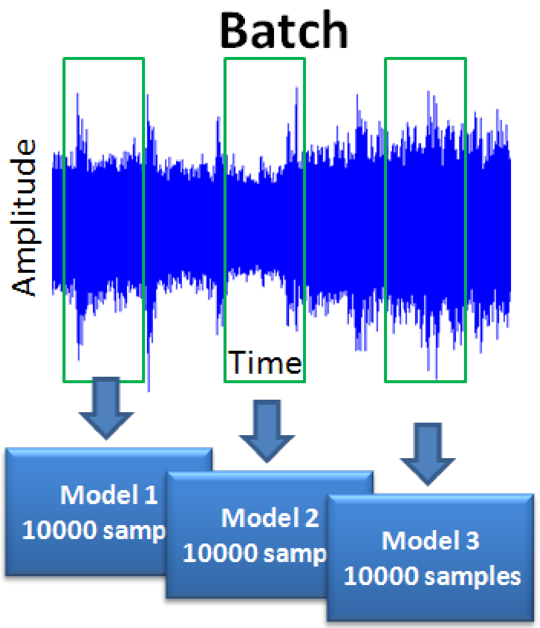
Position #	Force F [N]	Deflection R_{max} [μm]	Position #	Deflection R_{min} [μm]
1.1	35	0	1.2	0
2.1	117	9	2.2	4
3.1	233	27	3.2	15
4.1	350	47	4.2	26
5.1	467	66	5.2	38
6.1	583	88	6.2	50
7.1	700	114	7.2	62

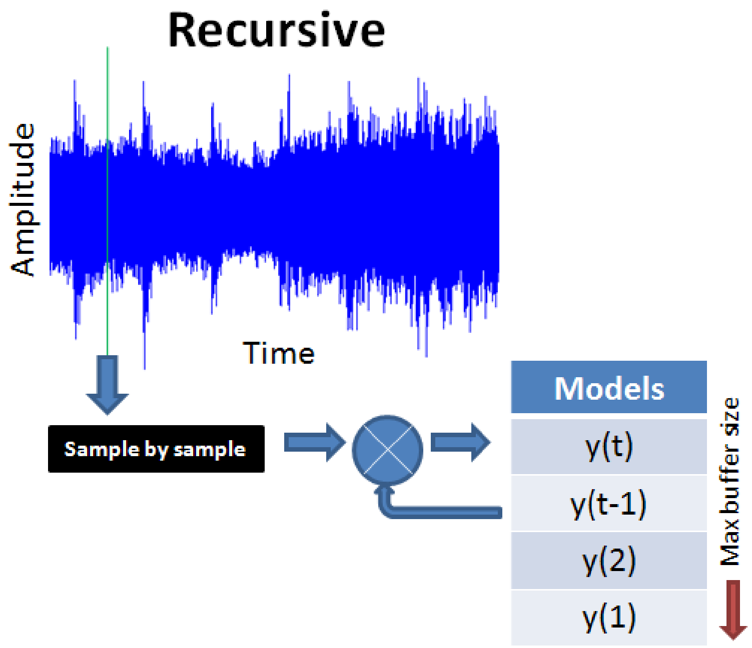
$$k_{s\,\mathrm{min1}} = \frac{F(2.1) - F(1.1)}{R_{\mathrm{max}}(2.1) - R_{\mathrm{max}}(1.1)} \Rightarrow k_{s\,\mathrm{min1}} = 9 \ \ \mathrm{N/\mu m}$$

$$k_{s\,\mathrm{min2}} = \frac{F(7.1) - F(2.1)}{R_{\mathrm{max}}(7.1) - R_{\mathrm{max}}(2.1)} \Rightarrow k_{s\,\mathrm{min2}} = 6 \ \ \mathrm{N/\mu m}$$

Identification model

Batch and recursive (adaptive) estimation



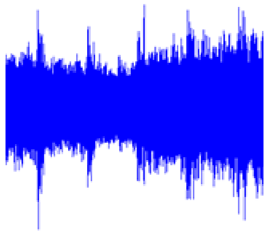


- Stationary systems
+ High accuracy
+ Optimized model structure and order
- Average behaviour of the system
- Long time to process data

- Time-varying systems
+ Each sample one model
- Model structure and order *a priori*
- Less accuracy

Validation

Select the model, the model order, sampling interval and check the fitness

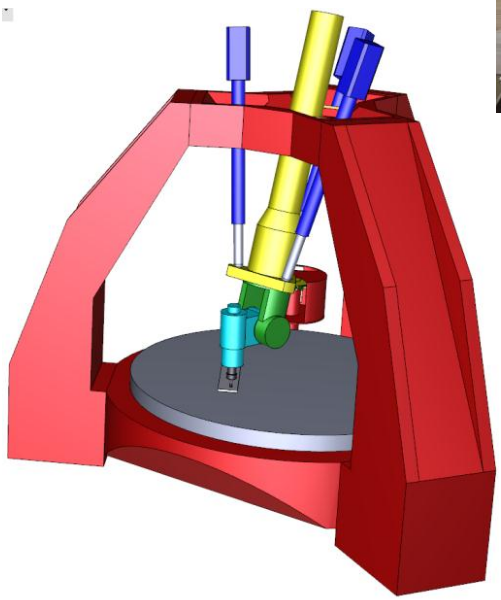


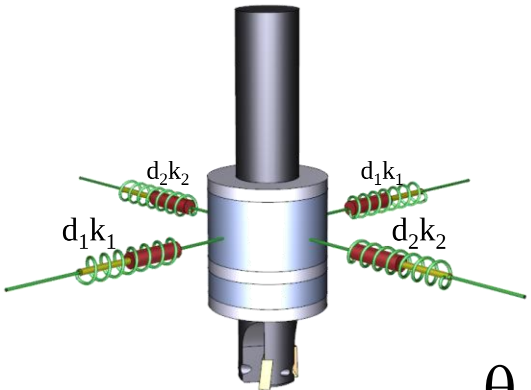
Machine tool response

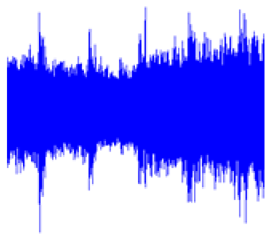
Identification model

Technique for recursive identification of modal parameters

Criterion to discriminate between forced and self-excited oscillations







$$\theta(t) = \begin{bmatrix} \omega_{op,1} \\ \vdots \\ \omega_{op,p} \\ \xi_{op,1} \\ \vdots \\ \xi_{op,q} \end{bmatrix}$$

θ_{ref}

Experiments

Two purposes of the experimental part

1. Demonstrate the recursive identification techniques ability to estimate the time-varying modal parameters.
2. To compare the modal parameters with the operational dynamic parameters of en end-milling operation.

Machine tool: Hybrid parallel kinematic structure

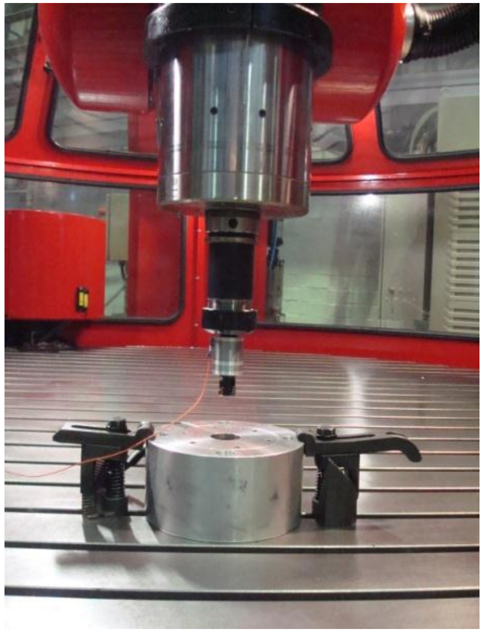
Spindle system: IBAG HF 170, *n*=0-24000 rpm

Contact-less excitation system: Modified active magnetic bearing unit

Response sensor: 3-directional accelerometer

Tool: Modified 3 tooth CoroMill R390

Experiments

Traditional testing	New method, structure testing	New method, PMI testing
		
EMA (n_s=0 rpm)	Recursive estimation ($n_s \geq$ 0 rpm)	Recursive In-process testing

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Thank You for Your attention!