PHM for machine capability

Jaydeep Karandikar
R&D Staff
Oak Ridge National Lab
Manufacturing Demonstration Facility
karandikarjm@ornl.gov

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Machining and Machine Tool Research and Development

Making better use of the existing installed machine tool base

- Move from a geometry focus to a performance focus

- The complete system: tool, tool holder, spindle, machine, ... matters

- Make it easy to access the data

Creating new machines for new needs

- Hybrid systems

- Small machines, big parts

- Machines for freeform optics

Workforce development

- Complete spectrum: operators to thought leaders
Are all my machines equally capable?
Machining dynamics

Frequency response function

Stability lobe diagram

Unstable (chatter)
Identical machines? Different dynamics

Case 1

Case 2

Stable cutting conditions for one machine – unstable for other

Change in stiffness and natural frequency

Real (m/N)

Imag (m/N)

Axial depth (mm)

Spindle speed (rpm)
Identical machines? Different dynamics

• Machine spindle dynamics depend on:
  – drawbar force
  – retention knob
  – spindle bearing pre-load

• Identical machines may start with different dynamics and they change over time.

• Process parameters converge towards the worst machine.
Machine capability

If a good program stops working:
- excessive tool wear/tool breakages
- machining chatter
- recuts and rework
- part quality

Something is wrong – it is a maintenance issue and not a normal condition.
PHM needs for machine capability

• Monitor machine health for process capability:
  – spindle dynamics
  – machine axis errors

• Model machine health in terms of process capability and part quality:
  – recommend corrective actions
  – optimized and defect-free machining process
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