

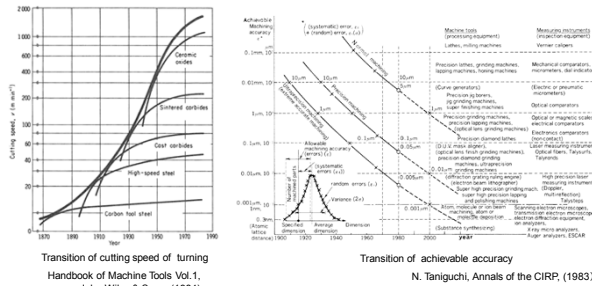
Improvement of CNC lathe design to reduce thermal displacement

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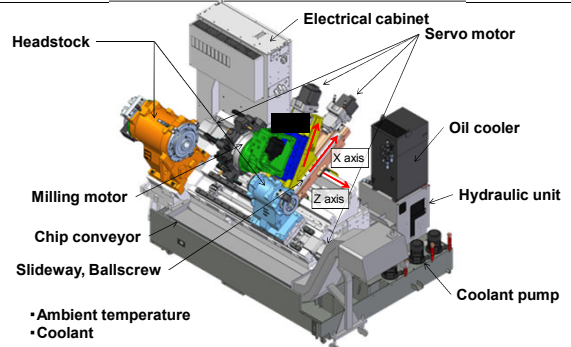
Thermal displacement on NC Lathe

- Demand for higher accuracy NC lathes increases
 - Thermal displacement contributes major machining errors
 - Thermal displacement of NC Lathe is affected by following factors
 - Machine structure
 - Ambient temperature
 - State of heat sources
 - Airflow condition
 - Coolant usage
- These factors complexly influence thermal displacement.

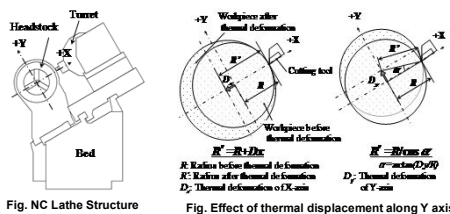
Speed and accuracy improvement of CNC lathe



Basic structure and heat sources of CNC lathe

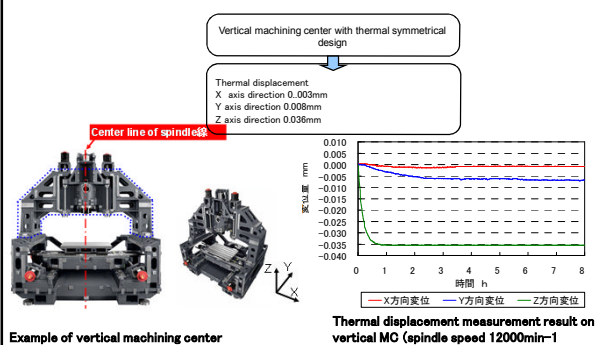


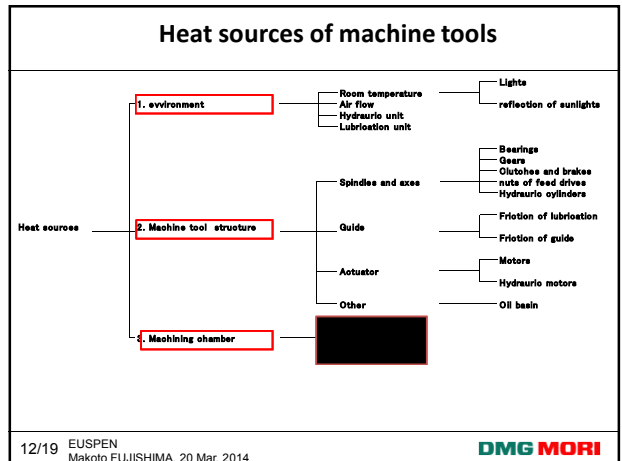
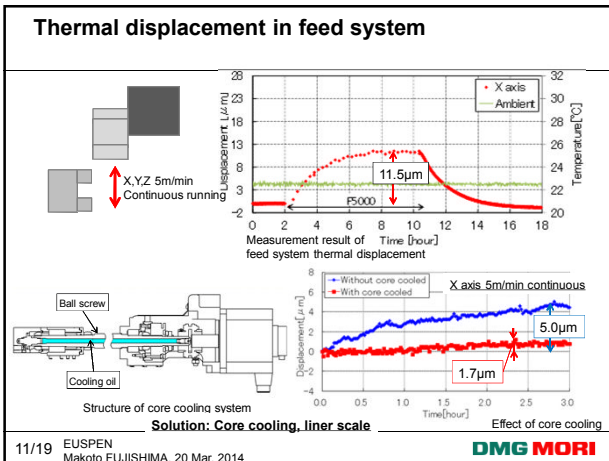
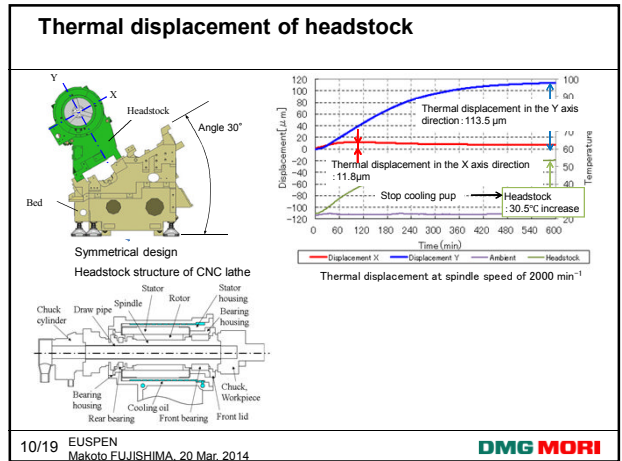
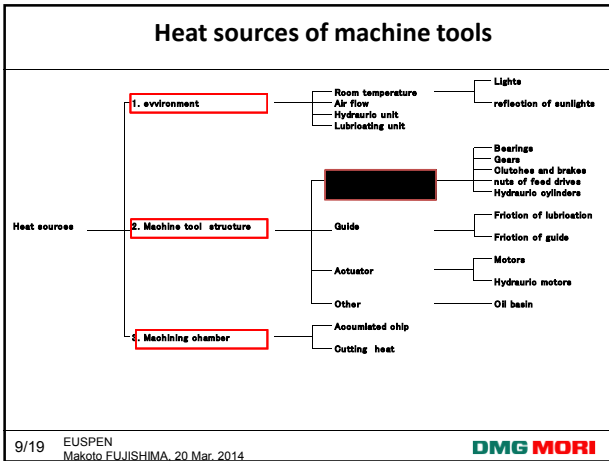
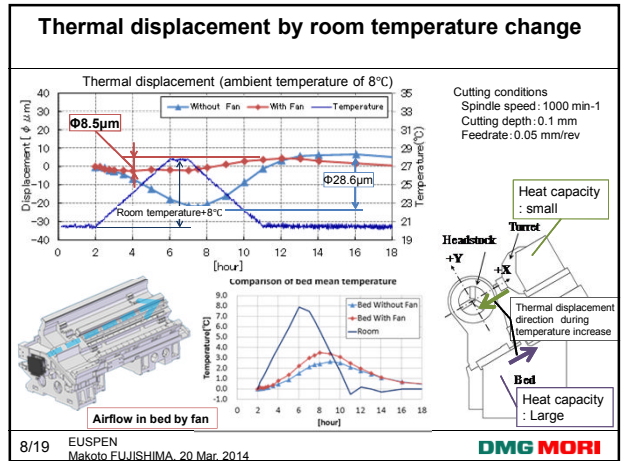
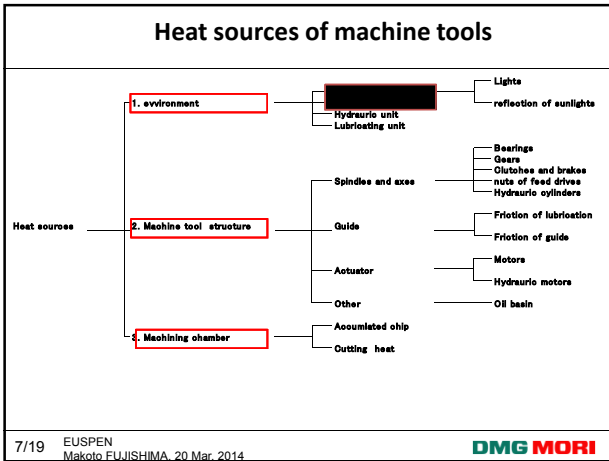
Headstock structure and thermal displacement influence



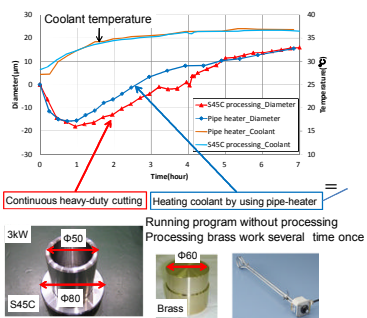
- Thermal displacement on Y axis is smaller than that on X in terms of direct diametrical influence.
e.g. Workpiece (R=50mm), thermal displacement on Y axis is 0.1mm (Distance between workpiece axial and cutting point). After thermal displacement, R is 50.0001mm
- Focus X-axis thermal displacement in this research.

Machining center example





Influence of coolant temperature change on machine accuracy (1)

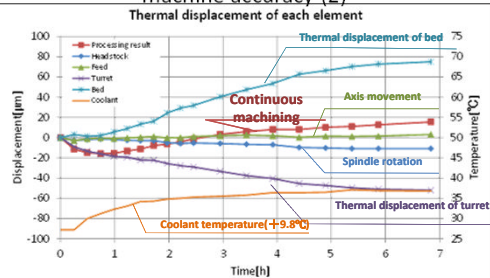


Coolant temperature was reproduced during heavy-duty cutting by using pipe heater

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Influence of coolant temperature change on machine accuracy (2)

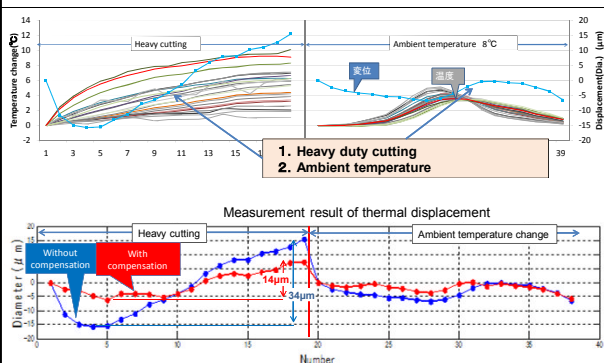


Difficult to balance thermal displacement between bed and turret because thermal capacity is not same. Thermal compensation is necessary.

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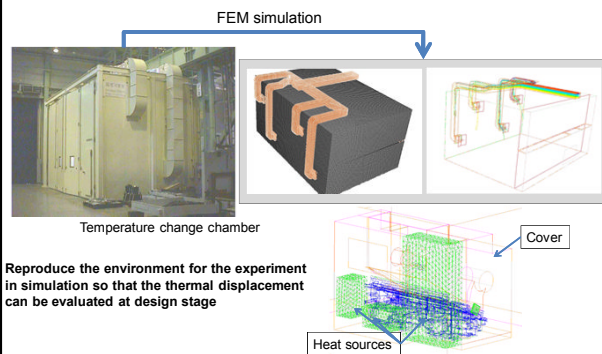
Consideration of thermal compensation



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Thermal displacement test at design stage

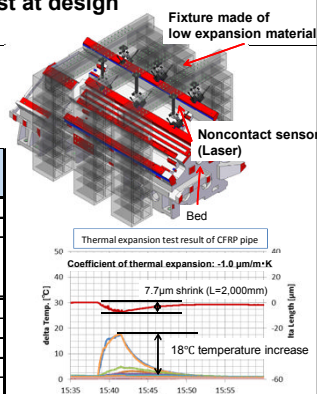


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Thermal displacement test at design stage

Material	coefficient of thermal expansion (10 ⁻⁶ /K)
Celamic	≦ 0.02
CFRP	≦ -0.6
LEX-SF1 low expansion cast iron	≦ 0.8
Granite	8.3
Cast iron	12
Steel	11
Stainless steel	17
Aluminum	23



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Conclusion

- Ambient temperature
Thermal displacement can be reduced by making saturation time of bed temperature shorter
- Headstock
The heat-symmetrical structure to reduce the thermal displacement
- Feed system
Thermal displacement is not big and can be improved by core cooling or linear scale
- Cutting heat
Thermal compensation is necessary because it is difficult to balance thermal displacement between bed and turret
- Analysis and measurement
Conducting analysis and measurement at design stage is important

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