

FEA based Prediction of Thermo-Structural behavior of Vertical Machining Center

Machine tool center has 40-70% of Machining error due to thermal issues. The prediction of thermal behavior of Vertical Machining Center due to environmental temperature variation using COMSOL-Multiphysics.

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Abstract:

Today's manufacturing industries like automobile, aerospace and Machine tools are demanding more accurate machined parts. Machine tool center has 40-70% of Machining error due to thermal issues. Temperature rise creates non-linear thermal deformation of machine. Significant cause of temperature rise due to friction at internal heat sources are motors, spindle bearings, belt drives and axis drives, while external heat is

due to the environmental effect. Finite Element Methodology helps in reducing time and cost associated to thermal experiments on Machine. This study focuses on the prediction of thermal behavior of Vertical Machining Center due to environmental temperature variation using COMSOL-Multiphysics

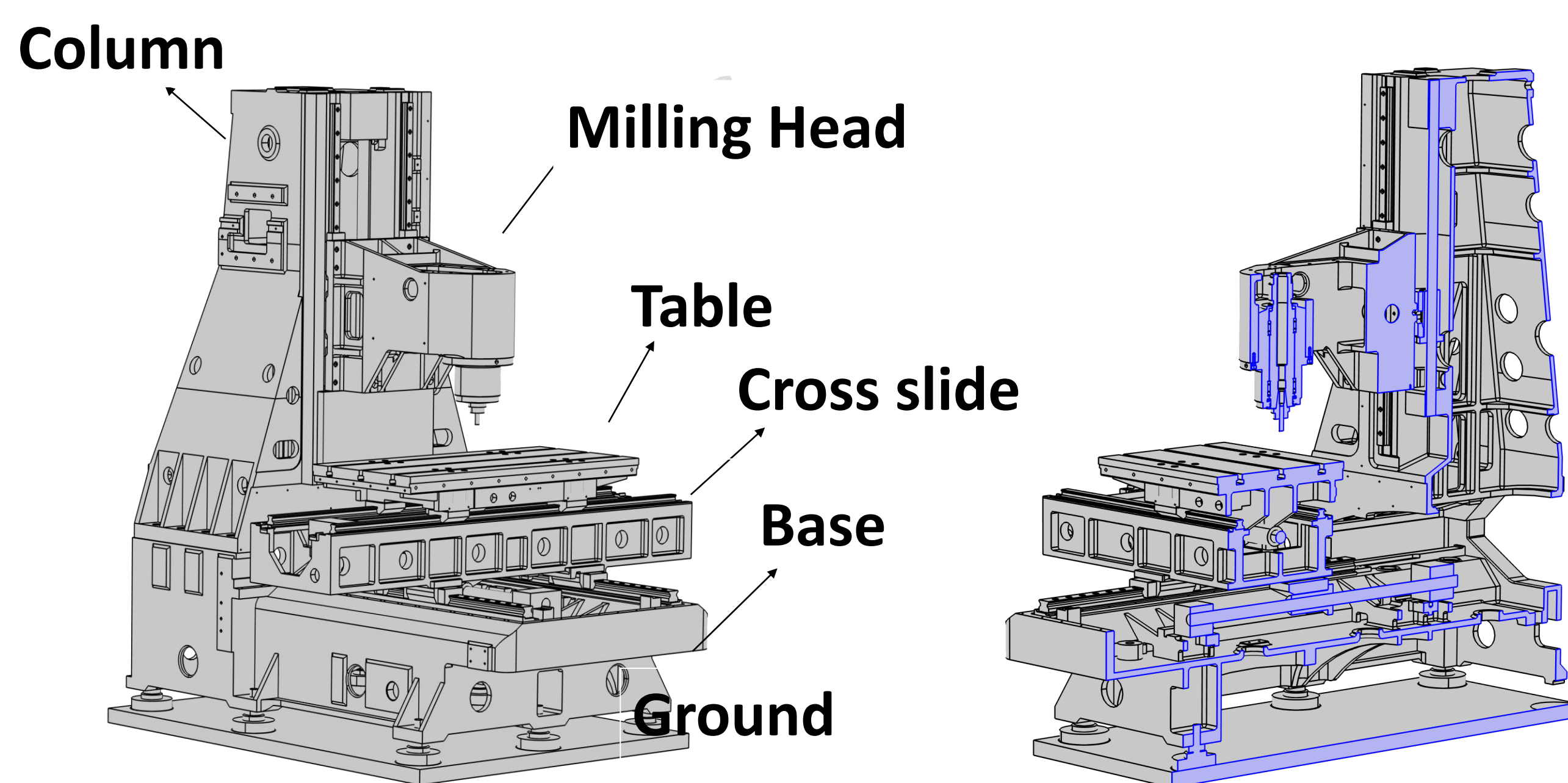


Fig.1 VMC machine

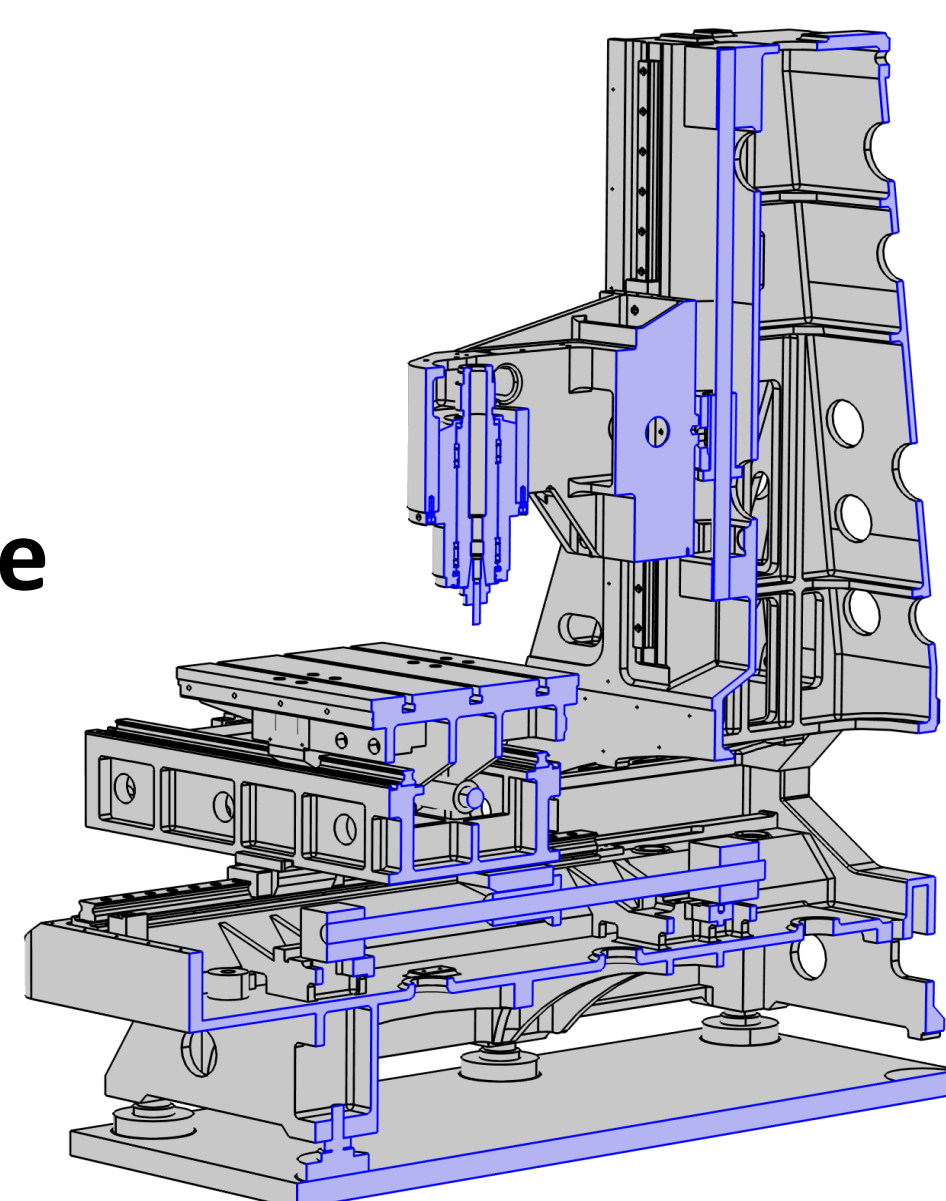


Fig.2 symmetry view

Methodology:

Governing equations: The heat conservation equation for a machine tool component

$$-h \cdot A1 \cdot (T1 - Te) = \rho \cdot V \cdot Cp \frac{dT1}{dt} + r12 \cdot A12 \cdot (T1 - T2)$$

TCC at the joint interface is calculated using the Mikic model

$$r12 = 1.9 \frac{ks}{\sigma s} \cdot \left(\frac{P}{E}\right)^{0.94}$$

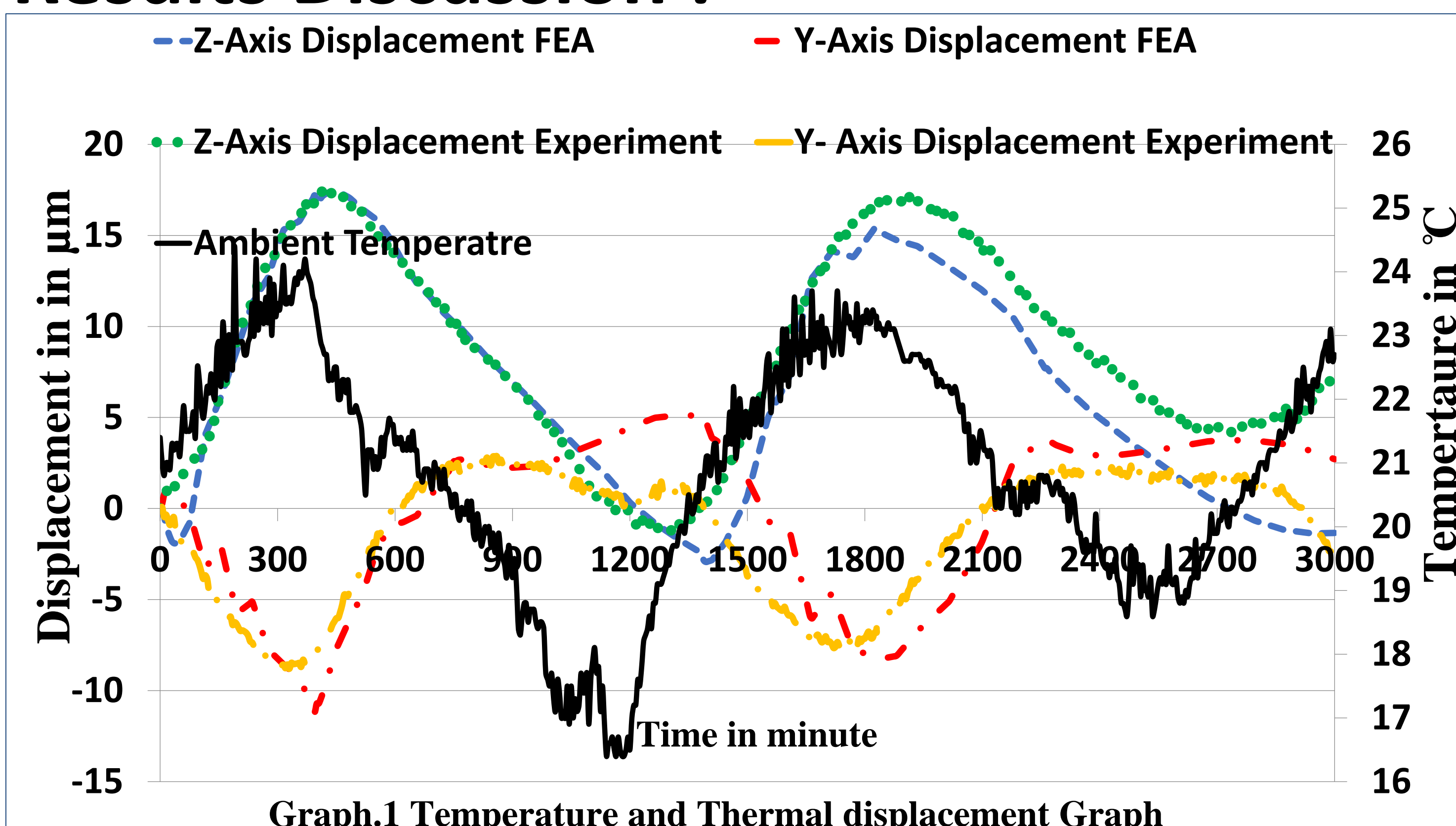
Thermal expansion in X-direction:

$$\delta x = \sum_{j=1}^n \alpha_j x L^x_j \delta T_j$$

Physics considered:

1. Solid mechanics
2. Heat transfer in Solids

Results Discussion :



Graph.1 Temperature and Thermal displacement Graph

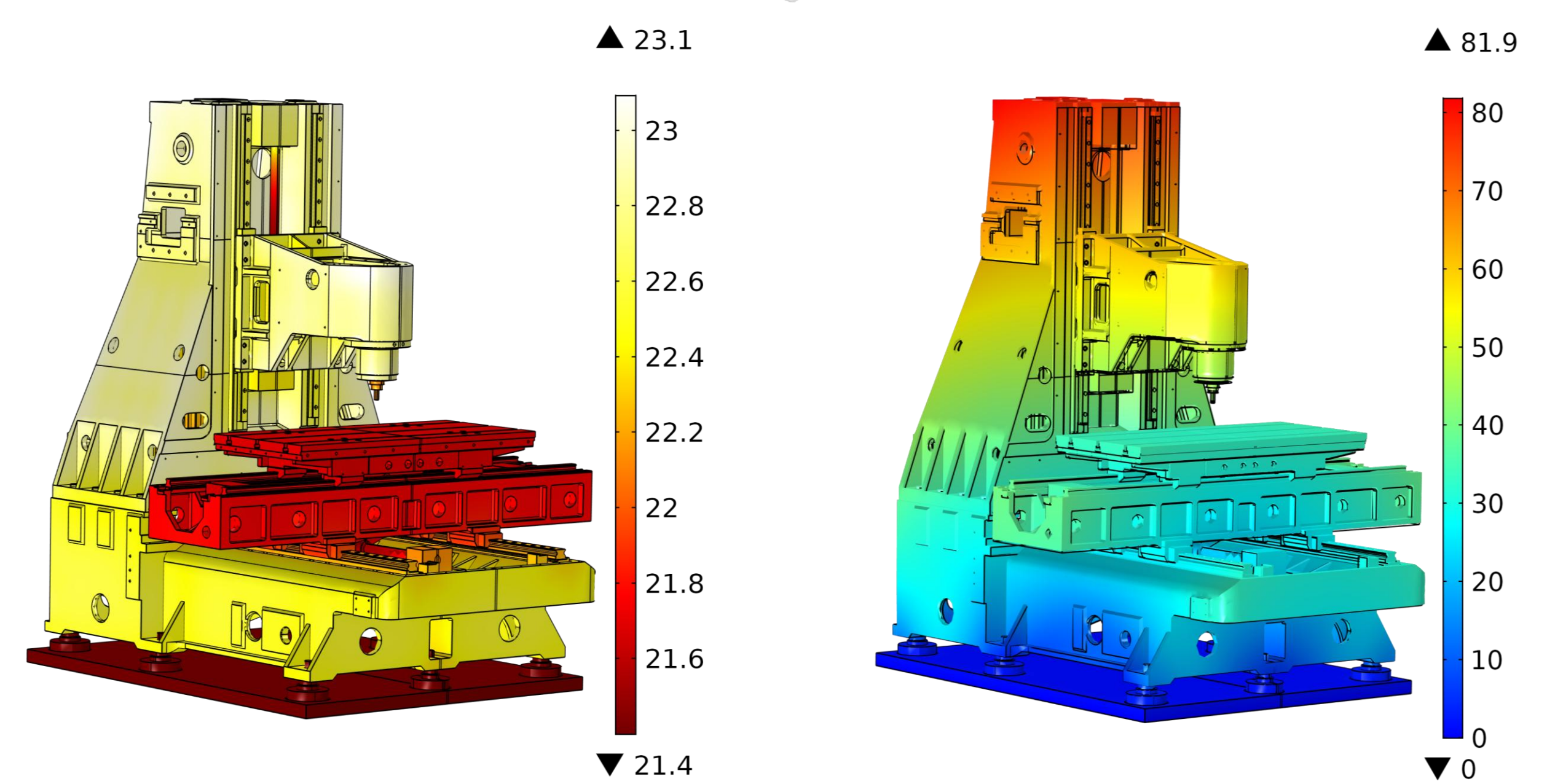


Fig.3 Temperature distribution Fig.4 Displacement of machine on machine

➤ Results of FEA data are presented that show that the FEA-based method correlated well with the experimental results resulting in the 80-85 % of accuracy.

REFERENCES

1. Naeem S. Mian*, S. Fletcher, A.P. Longstaff, A. Myers, "Efficient estimation by FEA of machine tool distortion due to environmental temperature perturbations", Page numbers (8), 2012
2. Mallinath N. Kaulagi and Harshad A. Sonawane, "Thermal network-based compensation model for a vertical machining center subjected to ambient temperature fluctuations", Page numbers (24), 2021
3. Mian, Naeem S. , "Efficient machine tool thermal error modelling strategy for accurate offline assessment ", *Journal*, Volume (vol.), Page numbers (217), 2010

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