INTRODUCTION
Giant floor type boring machines operate milling, boring and drilling processes on mega-size workpieces for the construction, oil field, wind energy, plant, shipbuilding industries. To make giant machining volume, they are made of boring and milling spindle (W-axis) assembled on the ram (Z-axis) as shown in Fig. 1.

Its machining accuracy depends upon deviation from the planned relative movement between the tool center point (TCP) and the workpiece. For machine tools, this relative error is called the volumetric error. This is generated from joint errors of moving axes and shape deformations from the machine tool structures. As strokes of the X, Y, Z axes are over several meters, and the workpiece is too big, machining time takes several hours. Contrary to small-size and regular machine tools, volumetric error of the giant machine tool degrades machining accuracy. It depends upon non-repeatable joint and shape deformation errors due to internal and external thermal error sources. In previous papers [1-2], to estimate thermal deformation of the giant machine tool, kinematic error models of joint and shape error elements were formulated through first order transfer functions of them. Thermal gains, time constants of the transfer functions were formulated through heuristic approaches.

Contrary to previous heuristic approaches, finite element methods have been applied to study thermal characteristics and mechanisms of thermal deformation in small-size and general machine tools [3-4]. Haitao, et al. [3] applied FEM to study thermal behavior of a turning center spindle. To develop precision machine tools, Jedrzejewski, et al. [4] studied an estimation method of temperature distribution and thermal deformation for machine tools. They suggested a FEM-based simulation methods for design of precision machine tools.

In this paper, to identify accurate thermal deformation transfer functions of the shape error elements without experiments, formulation of a computational error model for the column element in the giant floor type boring machine will be conducted through FE analysis. Ansys APDL will be applied to predict temperature distribution and thermal deformation of the column accurately. Ambient temperatures, and frictional heats of the ballscrew shaft-nut interface and supported bearings are to be applied as external and internal heat sources.

SHAPE ERROR ELEMENT BY FEM
Fig. 1 shows schematic diagram with coordinates of the giant floor type boring machine. It consists of the floor bed, column, head, ram, etc. As the height of the machine is over 15 meters, thermal deformation behavior of the column is a dominant shape error. In this paper, accurate shape error element of the column is to be formulated through finite element modeling.

Fig. 2 shows ambient temperatures measured in the factory according to each 2m height above the base level. Temperature difference around 1.5°C between bottom and top of the column acts as an external heat input. Diurnal range of 9°C acts another external heat source. Heat generations due to frictional heats at the ballscrew shaft-nut interface and support bearings are to be modeled as internal heat sources. Heat flux due to convection from the head unit is to be included as another internal heat source for the accurate shape error model derivation.

Fig. 3 shows a FE model to conduct thermal analysis of the column. Fig. 4 shows a simplified finite element model of the column and the ballscrew system. Time-varying shape error element of the column is to be identified through curve-fitting of FE results according to operating conditions of the machine tool.
REFERENCES


FIGURE 1. Coordinate Systems of the Floor Type Boring Machine.

FIGURE 2. Temperature record for 24 hours according to height difference in the factory.

FIGURE 3. FE model of the column.

FIGURE 4. FE shape error element of the column.