Abuaniza, Ayman, Fletcher, Simon and Longstaff, Andrew P.

Thermal error modelling of a three axes vertical milling machine using Finite element analysis (FEA)

**Original Citation**


This version is available at http://eprints.hud.ac.uk/id/eprint/19369/

The University Repository is a digital collection of the research output of the University, available on Open Access. Copyright and Moral Rights for the items on this site are retained by the individual author and/or other copyright owners. Users may access full items free of charge; copies of full text items generally can be reproduced, displayed or performed and given to third parties in any format or medium for personal research or study, educational or not-for-profit purposes without prior permission or charge, provided:

- The authors, title and full bibliographic details is credited in any copy;
- A hyperlink and/or URL is included for the original metadata page; and
- The content is not changed in any way.

For more information, including our policy and submission procedure, please contact the Repository Team at: E.mailbox@hud.ac.uk.
Abstract
The errors caused by thermal deformation directly affect the precision of a machine tool. Temperature changes of machine tool structures occur as a result of two reasons: firstly, internal heat sources like belt drives, motors, and bearings. Secondly, external heat sources such ambient temperature change of the work shop. These changes in machine tools structure temperature cause the heat to flow and because of this the machine tool element deforms.

Objectives
- Measuring temperature gradient and displacement of machine tool structures.
- Creating a FEA model and simulating the temperature and displacement of machine tools.
- Comparing the experiment and simulated data.

Methodology
Experiment: The experiment setup divided into parts

1- Thermal imaging camera setup

![Thermal imaging camera setup and end of heating cycle](image)

2- Non-Contact Displacement Transducer Sensors (NCDT)

![Non-Contact Displacement Transducer Sensors (NCDT)](image)

Creating FEA model and simulating it

Model simulation
The FEA was carried out using Dassault Systemes Simulation (Part of the Solidworks suite of software) to predict the temperature gradient and the spindle thermal deformation.

Results

<table>
<thead>
<tr>
<th>Correlation coefficients (R)</th>
<th>Temperature</th>
<th>Displacement</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0.92</td>
<td>0.97</td>
</tr>
</tbody>
</table>

Conclusion
The accurate simulations can be used to predict errors under different operating conditions and to develop compensation models. Thermal error could be reduced to just 4 μm in the Z and Y axis directions from 35 and 20 μm respectively.