University of Huddersfield Repository

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.

http://eprints.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 as ambient temperature change of the working 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 components
- Creating a FEA Model and simulating the temperature and displacement of machine tools
- Comparing the experiment and simulated data

Methodology

Experiment: the experiment set up divided into parts

1. Thermal imaging camera set up

Thermal imaging camera set up and a thermal image at end heating cycle

2. Non-Contact displacement Transducer Sensors (NCDT)

NCDTs use a magnetic field to sense the target

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

Heat power (Non linear heat source relationship)

Creating FEA model and simulating it

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