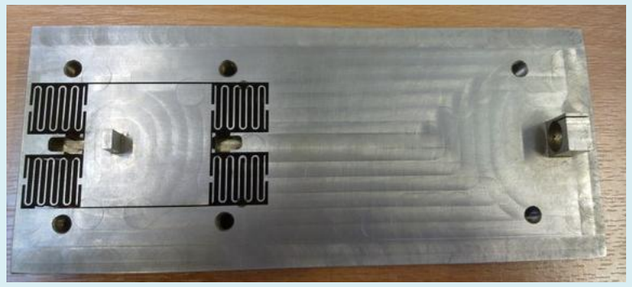
Design and building of Nano Positioning Stage

Introduction

The advent of new techniques to explore properties of atomic scale structures leads to the development of the new field of nanotechnology. In the past decade, it is said that nanotechnology will make fundamental contributions to most fields of science and technology. Certainly, the investigation of nanotechnology requires quickly accelerate positioning. This demand for ultra high positioning precision is an important requirement in many applications of nanotechnology. The aim of this project is to build and test a nano positioning stage, as well as investigating the dynamics of the system.

Design

A Nano positioning stage made of mild steel consists of several features, including a pair of flexure springs on each sides of the platform which provides no dry friction and backlash; LDV probe clamp; slots for actuator and sensor; laser beam reflection block. The design of these features was of vital importance to success of the project. Careful consideration had to be given to the choice of materials, selections of sensor and actuator. A PZT stack actuator is chosen, a PZT sensor in parallel with LDV sensor is chosen to be the sensing system for the stage.

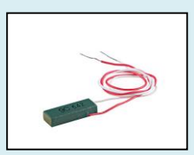


Choice of PZT sensor and actuator

Piezoceramic materials use piezoelectric effect to expand or contract itself when a voltage across it, thus act as an actuator, vice versa act as a sensor.

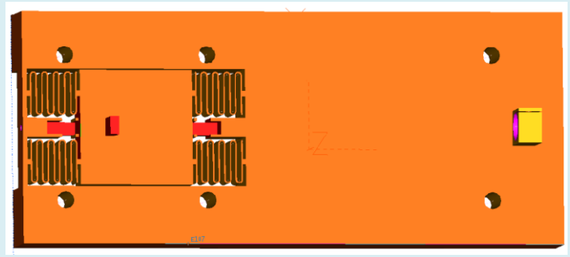
Feature of PZT:

- perform sub-nanometer moves at high frequencies
- Frictionless
- High load
- No maintenance and no wear.



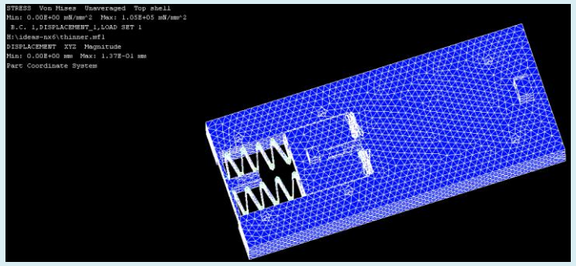
I-deas CAD tool

Usage of I-deas CAD drawing enormously eased the designing of the stage.I-deas CAD drawing provides powerful 3D solid modeling, and gives more accurate and easily read information to the workshop during manufacturing.



Finite Element Analysis using I-deas

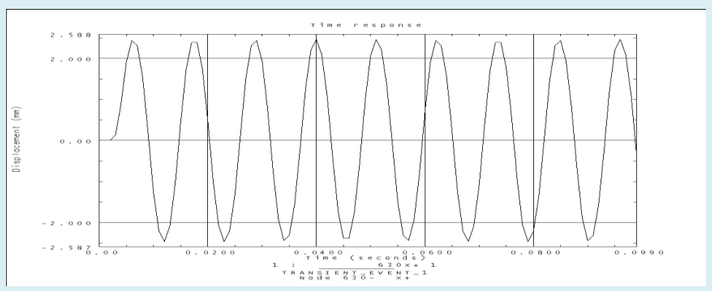
A Key method helps designing nano stage and making analysis of displacement, stress distribution.



The figure shows a finite element analysis of one of the design of the stage when the platform is under 100N of actuator force.

Dynamic Simulation of I-deas

Dynamic simulation by I-deas provides estimation of the dynamics of the nano stage. An investigation was made by applying a step force of 100N to the platform and simulate the response of the stage. Natural frequency 66 rads/s of the stage is found by information of the system response graph.



Investigation and test of nano stage

With the aim of determining the dynamics of the nanopositioning stage such as the resonance frequency, two different approaches were made for determining the dynamics, one was using dSpace, and the other one was using Siglab.

Natural Frequency-

1. dSpace approach:

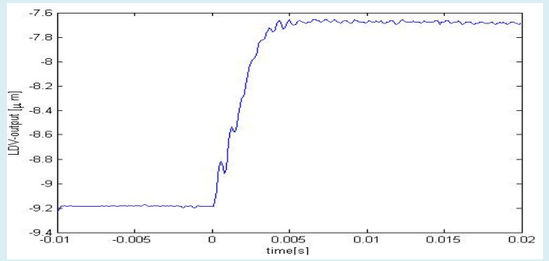


Fig above shows the output from LDV sensor, and natural frequency is found to be 1600 rads/s.

2. Siglab approach

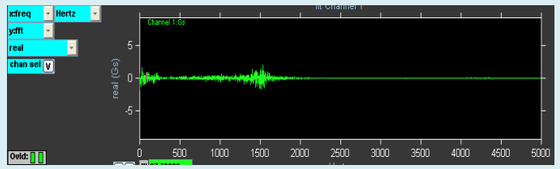


Figure above is a Fast Fourier transform of PZT output for PZT actuator subjected to random signal. A natural frequency about 1500 rads/s is found.

3.

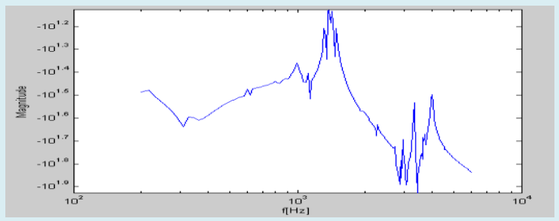


Figure above is the bode plot by PZT sensor output. A sharp peak in the magnitude plot indicates the resonance frequency which is at 1500rad/s.

Conclusion:

The design of the stage is successful, as it performs well during testing. Both of the two different approach of finding the natural frequency of the stage agree that the natural frequency is about 1500rads/s. Further work needs to be done to investigate the dynamics of the nano stage at low frequency, therefore comparison can be done to the natural frequency found in dynamic simulation of I-deas.

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