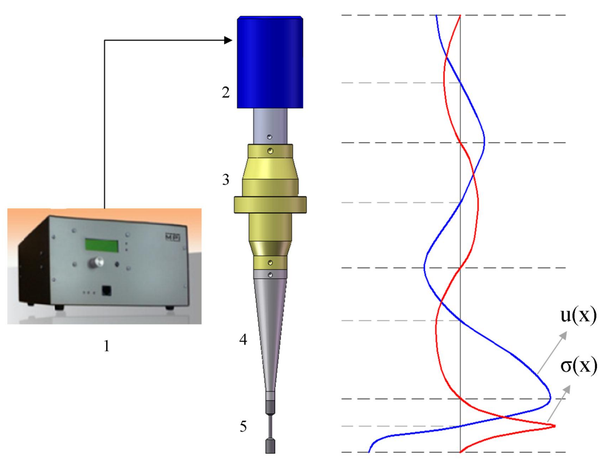
Modeling of Ultrasonic Fatigue-Life Testing Machine

Diyan M. Dimitrov*[1], Veselin Mihailov[1], and Borislav Kostov[3]
[1]Technical University of Varna, Bulgaria
*Bulgaria, 9010Varna, ul.Stiudentska 1, TU-Varna, dep. Technical Mechanics, dimitrov.diyan@gmail.com

.

Introduction: Nowadays, ultrasonic fatigue testing machines are used to perform materials testing in the range of 10e7 to 10e10 fatigue cycles at frequency 20kHz.
The main purpose of this study is to model the relation between the actuator power, the displacement amplitudes and the stresses in the specimen.

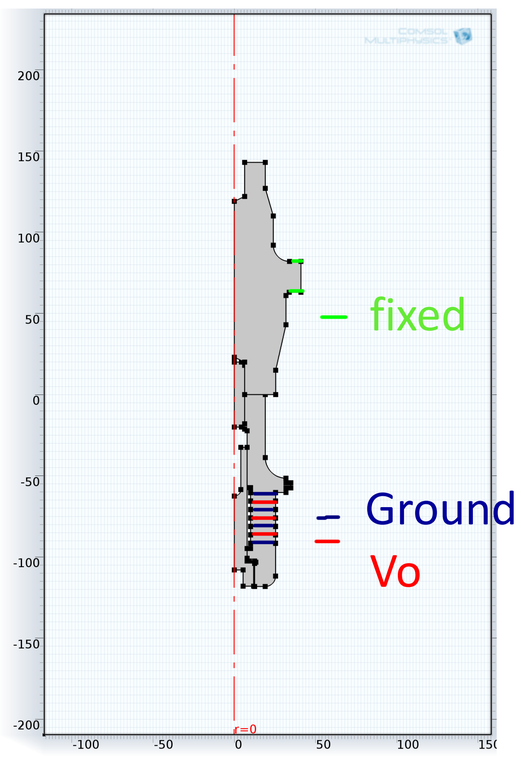


1-generator, 2-piezoceramic actuator, 3-booster, 4-horn, 5-tested specimen

Figure 1. Ultrasonic fatigue testing machine

Computational Methods: For eigenfrequency study and frequency response study analysis Comsol 4.2a Structural Mechanics Module was used. Piezoelectric Devices (pzd) physics, combining electrical and structural boundary conditions, was applied

.



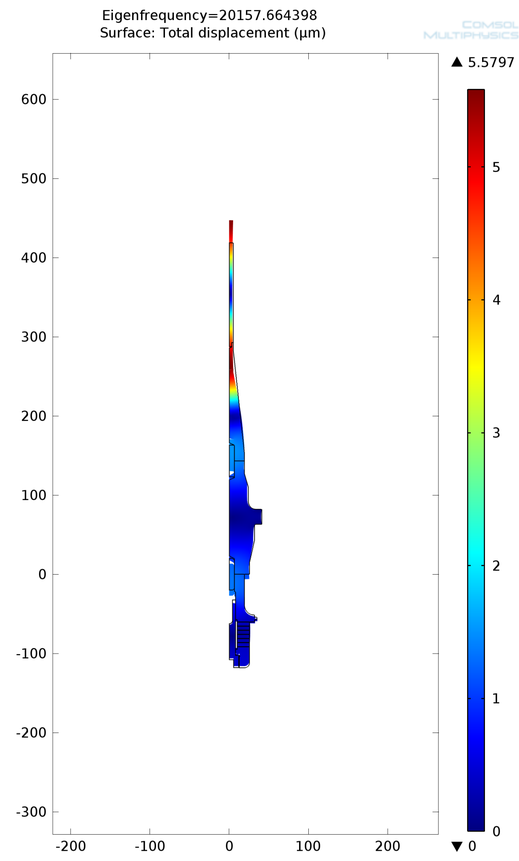
Transducer (up to3kW)
Booster 1:1.5 (Gold)
Produced from MPInterconsulting-Switzerland

Sonotrode – conical shape, 1:3.37,
Al 7075-T6

Test speciment – cylindrical shape ,L=126mm , made of steel

Figure 1. Geometry (transducer+booster) and boundary conditions

Results:



Eigenfrequency study
Vo=0, f=20158Hz, fig.3

Frequency response study
Vo=110V

At 20158Hz
Displacement amplitude, fig.4
Transducer -7μm ,Booster -8μm
Sonotrode, Specimen-31μm

Max stresses, fig.5
Specimen -156MPa
Sonotrode -28Mpa
Piezoceramic discs – 10MPa

Figure 3. Axial mode shape at 20158Hz (exp. 20180Hz).

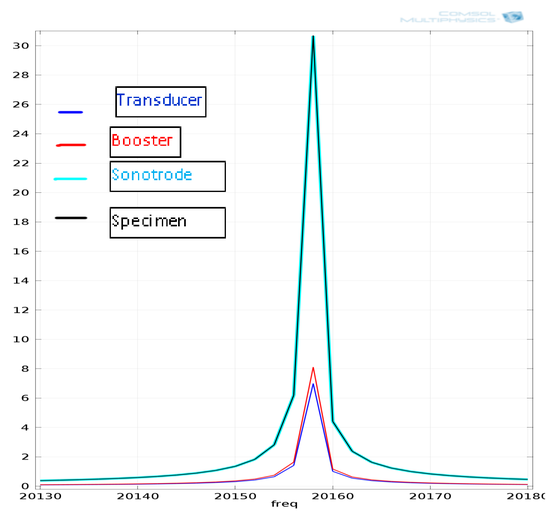


Figure 4. Displacement amplitude at the end of the transducer, booster, sonotrode, specimen

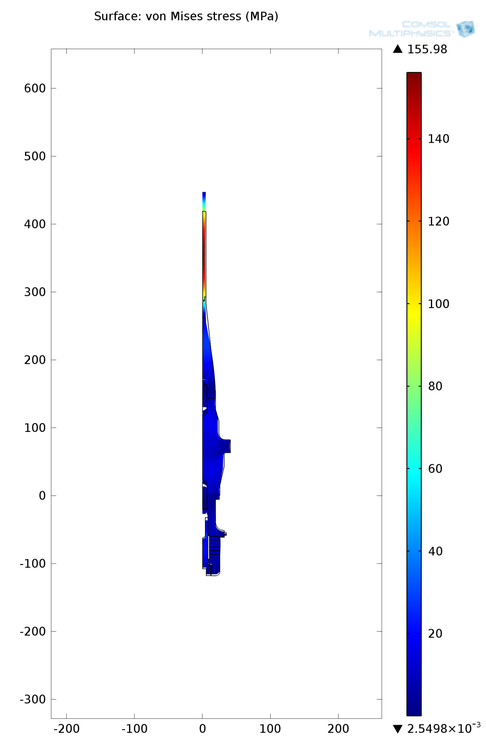


Figure 5. Stress distribution Vo=110V (20158Hz)

Conclusions: The determined eigenfrecuency shows good coupling with experimental results.
The harmonic frequency analysis gives the opportunity to predict displacement amplitudes and stresses in the tested specimen.

References:

1. Claude Bathias, Paul Croce Paris, Gigacycle Fatigue in Mechanical Practice, Marcel Dekker, - 304 pages (2005)
2. MPInterconsulting, www.mpinterconsulting.com
3. Introduction to Comsol Multiphysics, v.4.2a (2011)
4. Piezoelectric Shear-Actuated Beam, Comsol Multiphysics model library
5. Wuchinich D., FEA-Assisted Measurement of Young's Modulus and Poisson's Constant in Stout Horn Blanks, UIA 32nd Symposium (2002) www.modalmechanics.com

Acknowledgements
The authors gratefully acknowledge financial support from Bulgarian Scientific Research Fund, through the project DMU03/98