Highly Optimised Double Gimbal-Based Accelerometers with Piezoelectric Sensing Mechanism

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Introduction: A comparative study is done using optimized single axis accelerometer and dual axis and double gimbal accelerometers are designed with different cantilever beam types i.e. perforated, non perforated, spring type and cross spring type. The models are simulated to find the most sensitive model.

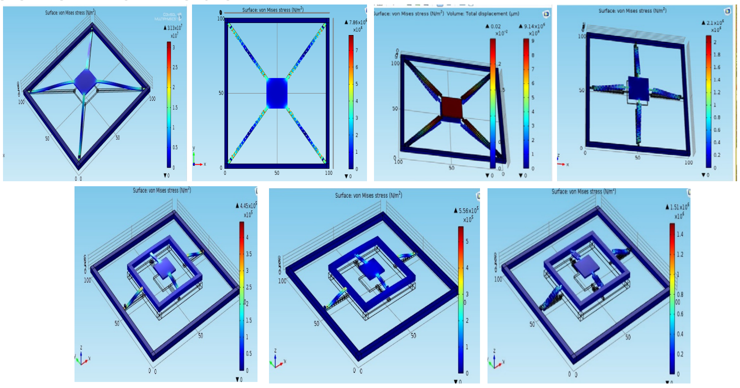


Figure 1. Dual Axis Non-Perforated type(a), Perforated type (b), Cross Spring(c), Spring type(d) and Double Gymbal Non-Perforated type(e), Perforated type(f), Spring type(g) Accelerometer on application of 100N force.

Computational Methods: : A single axis accelerometer is designed and optimised first for its cantilever beam dimensions and piezo electric sensor position and then for its housing. Based on this optimised model four dual axis and three double gimbal accelerometer are simulated.

The basic formulas used are for stress and displacement.

Stress is given by, $\sigma = \frac{P\,l}{z}$

Where, P = force per unit area (N)

l =length of cantilever beam (μm)

Z=section modulus of cantilever beam(μm^3)

and displacement is, $\delta_{\max} = \frac{P\,l^3}{3\,E\,I}$

Where

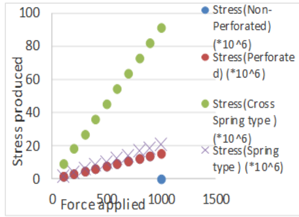
I = moment of inertia of cantilever beam,

E =young's modulus(N/m^2),

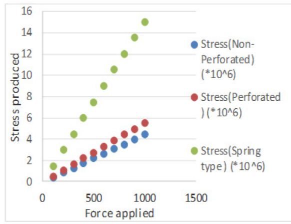
P = force per unit area(N/m^2)

l = length of cantilever beam(μm)

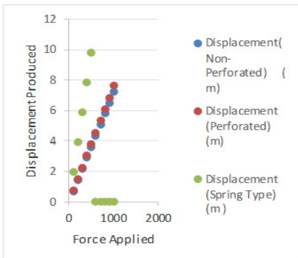
Results: In the stationary study the four models of dual axis are compared in the graph below. For the three models of double gimbal both time dependent and stationary studies are done and then compared.



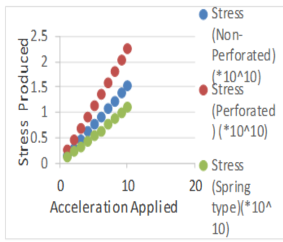
Graph1: shows the distribution of stress on application of force on all four models of dual axis accelerometer.



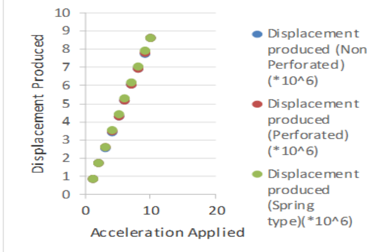
Graph2: Different values of force applied on all three models.



Graph 3: Force (N/m^2) on X axis and Displacement (μm) on Y axis for all three models.



Graph 4: Acceleration (m/s^2) on X axis and Stress on Y axis (N/m^2) for all three models.



Graph5: Acceleration (m/s^2) on X axis and Displacement on Y axis (μm) for all three models.

Conclusions: For stress as well as for displacement, in stationary study dual axis cross spring type and double gimbal spring type is more sensitive for applied force and In time dependent double gimbal perforated beam is more sensitive for applied acceleration

References:

1. T.Madhuranath*, R.Praharsha and Dr.K.Srinivasa Rao, Design and simulation of MEMS piezoelectric gyroscope Using COMSOL , comsol conference in Bangalore 2013.