Development of Linear Flexural Hinges

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Abstract- *A flexural hinge is a thin member that provides the relative motion between two adjacent rigid members through bending (flexing). Flexure joints are widely used to approximate the function of traditional mechanical joints, while offering the benefits of high precision, long life, and ease of manufacture. Micro and nano-positioning stages play a very important role in modern technology. It find applications in many fields, such as micromachining and scanning probe (such as scanning tunnelling, atomic force, etc.) microscopy. Different flexural based mechanism are developed for precise control/manipulation of position of object. These mechanism works on flexibility of material and gives frictionless, backlash free motion. Flexural joints are widely used in precision motion stages and micro robotic mechanism due to their monolithic construction. In current research paper analysis of Leaf hinge and right circular hinge based on stress and deformation is done for small micromachine application.*

Keywords- flexural hinge, compliant mechanism, deflection, stress.

I. INTRODUCTION

Complaint mechanisms achieve their motion out of deflection of flexible members. The advantages of such mechanisms include the elimination of friction, backlash and assembly, reduction in manufacturing cost, and increased precision. Flexure-based complaint mechanisms, which are utilizing flexure hinges as their flexible members, find wide use in variety of applications where high precision is required within relatively small workspaces.

A flexure hinge is a thin member that provides the relative rotation between two adjacent rigid members through flexing (bending), as shown in Figure 1.1, where conventional rotational joint is compared to a flexure hinge.

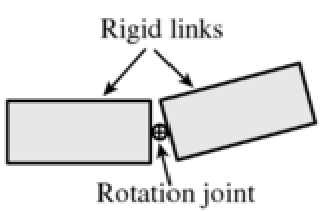

Figure 1. conventional joint

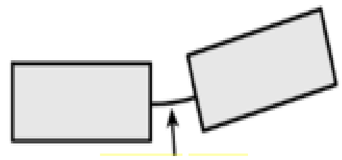

Figure 2. Flexural Joint

Flexural hinge consist of an elastically flexible, slender region between two rigid parts that must undergo relative limited rotation in a mechanism (which we call compliant due to presence of at least one flexible hinge) that is supposed to achieve specific task.the flexure hinge is monolithic with the rest of the mechanism for the vast majority of application, and this is secure of its advantages over classical rotational joints. We can Analyze flexural hinges based on following parameters:

1. Range of motion

All flexures are limited to a finite range of motion, while their rigid counterparts rotate infinitely or translate long distances. The range of motion of a flexible joint is limited by the permissible stresses and strains in the material. When the yield stress is reached, elastic deformation becomes plastic, after which, joint behavior is unstable and unpredictable. Therefore, the range of motion is determined by both the material and geometry of the joint

2. Stress

Most notch-type joints have areas of reduced cross-section through which their primary deflection occurs. Depending on the shape of these reduced cross-sections, the joints may be prone to high stress concentrations and hence a poor fatigue life.

3. Deflection

Deflection is the degree to which a structural element is displaced under a load. The deflection distance of a member under a load is directly related to the slope of the deflected shape of the member under that load and can be calculated by integrating the function that mathematically describes the slope of the member under that load

II. DESIGN OF FLEXURAL HINGES

For the Analytical Solution we used The Above formula to calculate stress,deflection and stiffness of the above mentioned hinges

1. Leaf Hinge

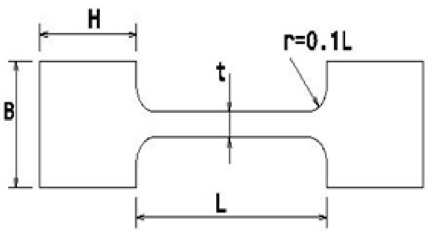

Figure 3.

$$\sigma = \frac{M}{I} y$$ ....stress equation

$$\delta = \frac{Wl^3}{48EI}$$ ....deflection equation

2. Right circular hinge

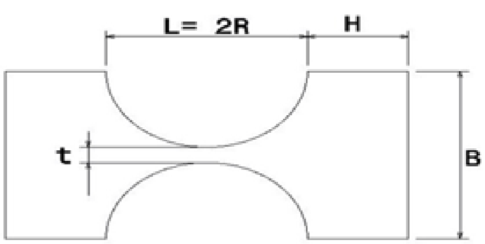

Figure 4.

$$\sigma_{nom} = \frac{4Et^{\frac{1}{2}}}{3\pi R^{\frac{1}{2}}} \frac{y}{I}$$ ....nominal stress

$$\sigma_{max} = k_b \times \sigma_{nom}$$

Where,

$$k_b = \frac{2.7t + 5.4R}{8R + t} + 0.325$$

$$\delta = \frac{9\pi F}{2Eb} \left(\frac{R}{t}\right)^{\frac{5}{2}}$$ ....deflection

We considere thickness of hinge from 0.5 mm to 1.5mm, L=5 mm to 15mm, P=5N

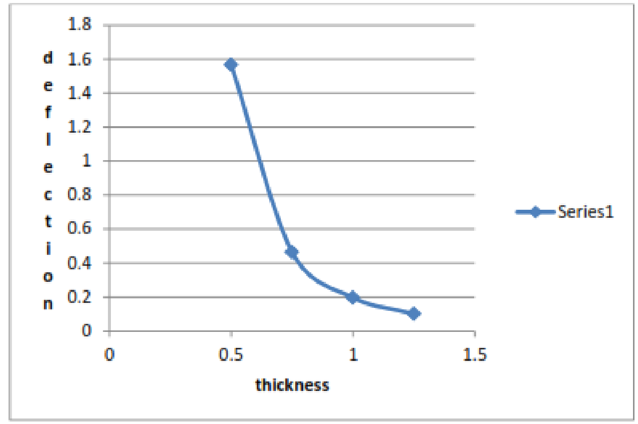

Figure 5. Graph of thickness Vs deflection for leaf hinge

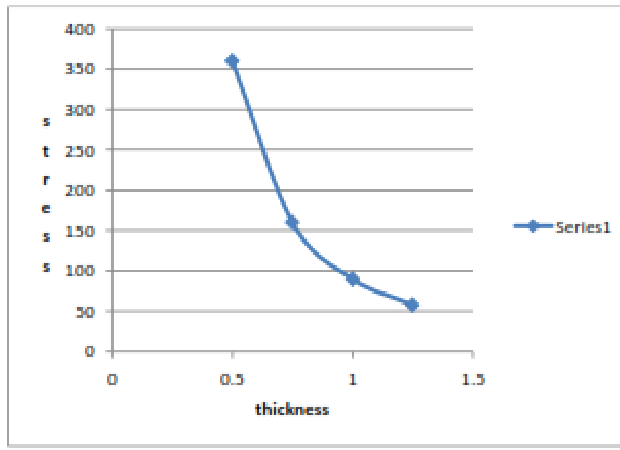

Figure 6. Graph of Stress Vs Thickness for leaf hinge

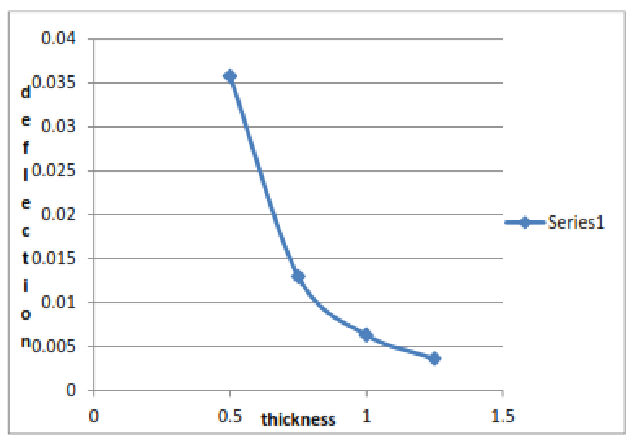

Figure 7. Graph of thickness Vs deflection for right circular hinge

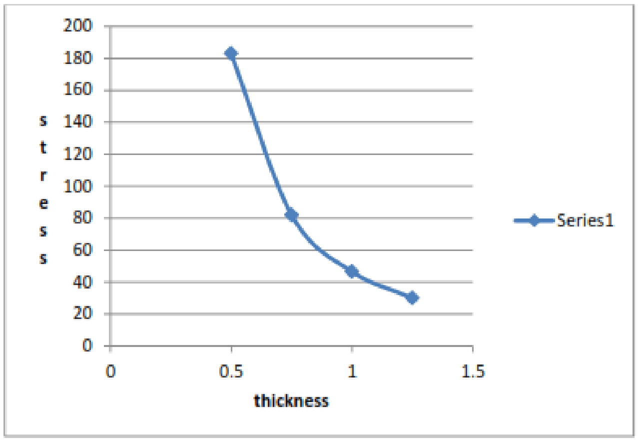

Figure 8. Graph of Stress Vs Thickness for Right circular hinge

From Chart 1&3 we got maximum deflection in leaf hinge as

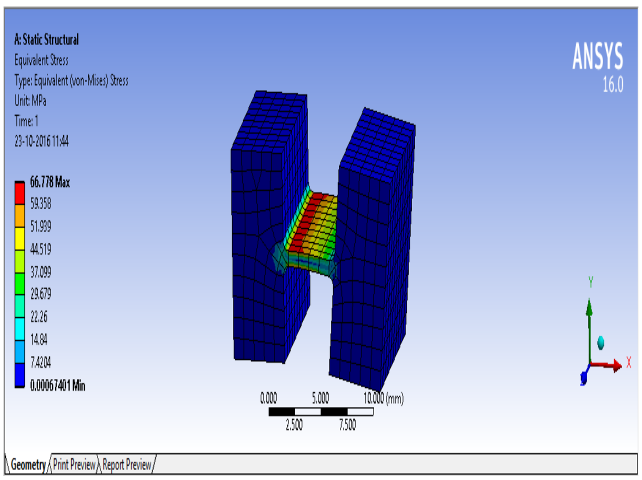

Figure 9. Stress Analysis of leaf hinge for 1mm thickness

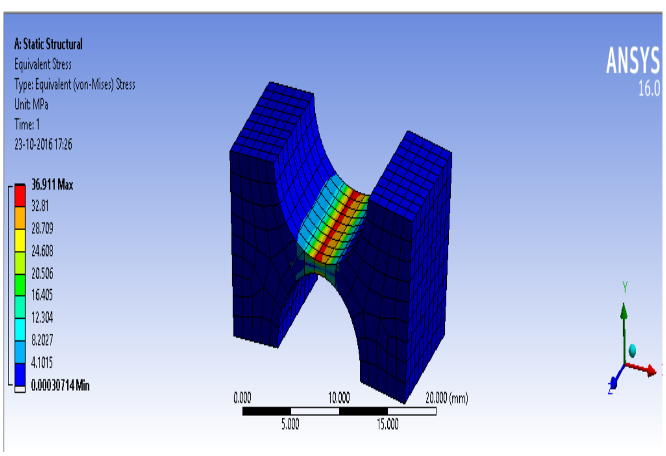

Figure 10. Stress Analysis of Right circular hinge for 1 mm thickness

From above analysis it is cleared that stress carrying capacity for 1mm thickness hinge is more in leaf hinge as compared to right circular hinge

III. CONCLUSION

For Small micromachine application we can use leaf hinge more effectively as compared to right circular hinge due to large deflection and load carrying capacity for the same dimension.

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