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Displacement Analysis of Compliant Mechanism

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Abstract: ***Everyone expects accurate outcomes in the fast-moving and extremely competitive globe today. The urgent need for precision led to developing new processes in a rapidly increasing mechanical and mechatronic globe, which serve the primary objective of accuracy. This special class of mechanism is called compliant mechanisms, which are used to improve the precision without compromising the accuracy of a member because of the steadiness and flexion. Motion is produced by the molecular deformation in compliant systems, leading to two main features of bending–soft movement and a tiny scope of movement. Scan The demand for contemporary techniques, for example the production of micronanos, characterization systems, such as microscopes is present in the scan processes. For the accurate control / manipulation of object position, different compliant based mechanisms are created. Flexures are compliant, elastic structures which produce smooth motions, tiny range and high resolution for their functionality. These processes can be used in precise apps such as micro soldering, lithographic micro-manufacturing wafer alignment. The primary aim is therefore to design an accurate system in a linear as well as in a rotational direction that gives accurate movement.The software of ANSYS is used to generate compliant mechanism parametric and static analysis models.***

Keywords: Compliant Mechanism, Precision motion in all directon.

I. INTRODUCTION

In today's world everyone wants precision motion in Micro-scanning and micro-manufacturing process. To achieve this precision special class of mechanism was developed which is known as compliant mechanism. It provides frictionless, backlash free, smooth and continuous motion. Compliant joints are used to provide smooth and guided motion, for example in precision motion stages as springs, to provide preload for example in a camera lens cap. Compliant mechanism works on material Elasticity. Motion is generated due to deflection of beam which gives smooth motion and small range of motion. Compliant mechanism with hinges is replacement for conventional hinges, by eliminating friction and backlash.

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II. COMPLIANT MECHANISM

A mechanism is device which is used to transfer motion and Energy.Traditional rigid-body mechanisms associated with links and joints. In Reciprocating Engine linear input is converted to rotary motion. In vice grip mechanism transfers energy from the input to the output

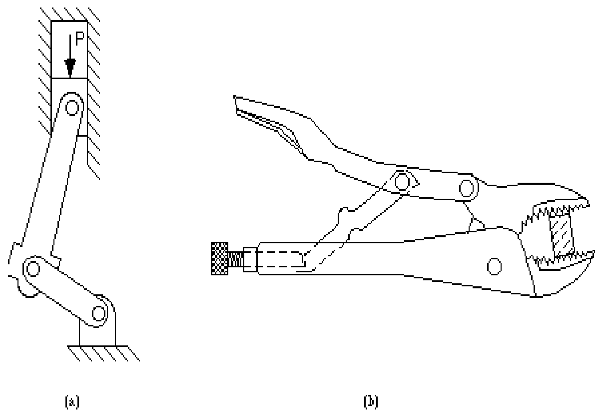
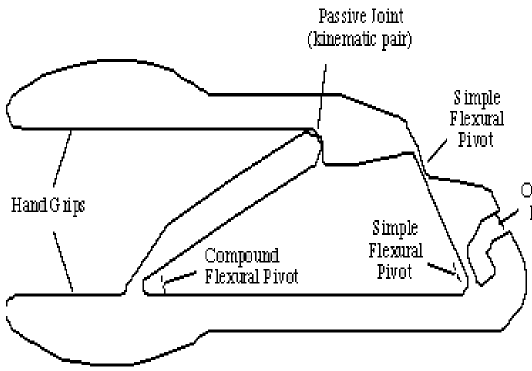
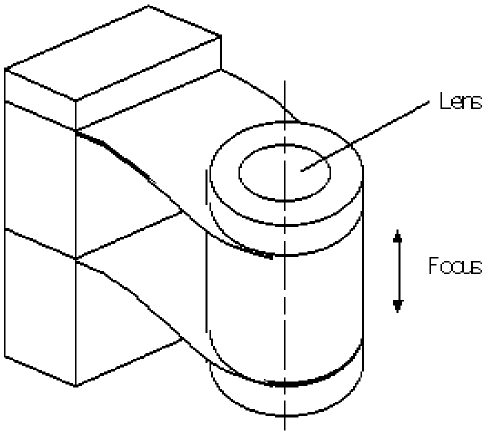


Fig. 1 Conventional Mechanism

A mechanism that complies transfers or converts movement, strength or power. However, compliant processes achieve at least some flexibility from the deflection of flexible joints instead of from mobile joints, as opposed to rigid links. Figure 2a provides an illustration of a compatible crimping mechanism. The input force, like the vice grip system, is now only stored in flexible members as stress energy. The input force is transmitted to the output port. it would be mobility-less, and it would be a structure if the unit were all stiff. Figure indicates a device used to concentrate a lens and needs compatible members to fulfill its function.



(a)



(b)
Fig.2 Compliant Mechanism

III. DESCRIPTION OF MECHANISM

In FIGURE 3., the system is made up of three linear beams attached to the outside frame and the motion stage at the center of the mechanism. The movement phase in the center is operated by the vice spindle engine. The beam is 100 mm long and the beam width is 1 mm. The beam is used. The length and thickness of the beam can be changed, but as we decrease the thickness of the beam, the rigidity of the beam is reduced and we get less moving. In the design of the compliance system the choice of materials also play a very significant role.Since the beam deflection and the young modulus are inversely proportional to each other, we must therefore choose the material with the smallest young modulus possible. So Beryllium Copper has lower young modulus than steel, but the price of BeCu is much higher than that of steel. During manufacture, care must also be taken not to induce residual stress. The force mechanism between 5N and 25N has been screened. We analyzed BeCu materials by choosing two and three linear beams for a system. we chose Stainless Steel Material for Double-compliant Manipulator.

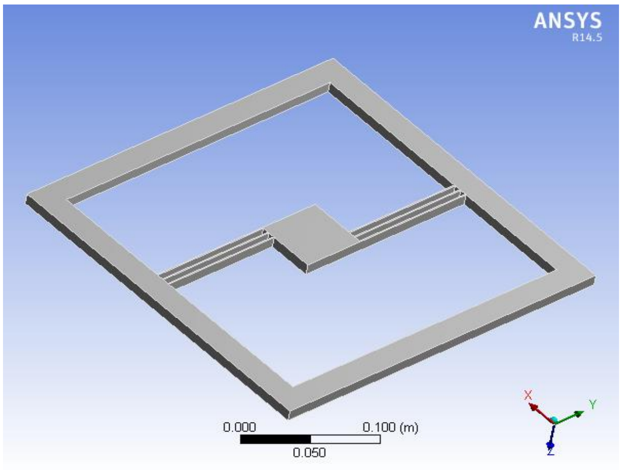


Fig. 3 Compliant mechanism using linear beam

Now, we will consider two cases for the mechanical mechanism, one of which has three linear beams and the second has two linear beams on each side of the movement stage. We also showed that the two mechanisms were different by analyzing Ansys. The square part in the center is known as the movement phase. It can either be used for the assembly of certain devices or by a scale, using the optical encoder to evaluate the displacement.

IV. ANALYSIS OF COMPLIANT MECHANISM WITH TWO AND THREE LINEAR BEAMS

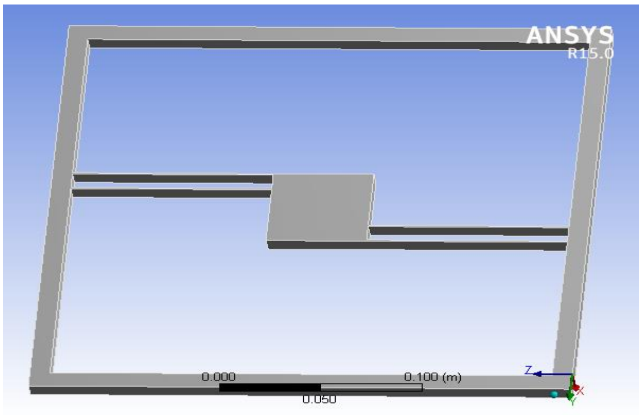


Fig.4 Compliant mechanism using two linear beams

We can obtain both linear and rotary motion in this system. A linear shift can be achieved by applying the force at the precise middle of the movement step. We can get rotational motion when we apply a force away from the centre. By the distance between the actuating force and the centre, the amount of rotational motion we can achieve can be changed. We have regarded two compliant mechanisms, (a) Compliant with two linear beams systems[Mechanism 1] (b) The compliant mechanism with three linear beams[Mechanism 2], but we can achieve maximum rotational mobility by applying force at the extreme end.

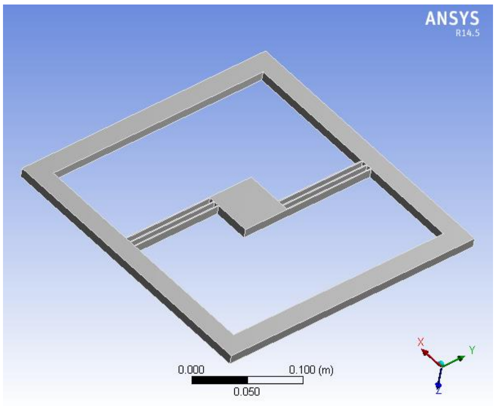


Fig.5 Compliant mechanism using three linear beams

4.1 Deformation with 5N force:

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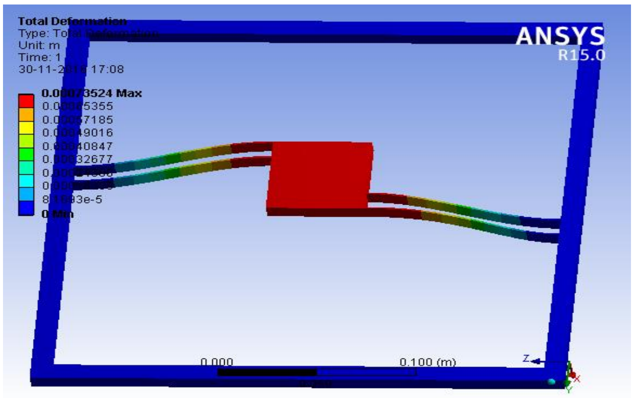

Fig.6 Deformation of Mechanism with two beam

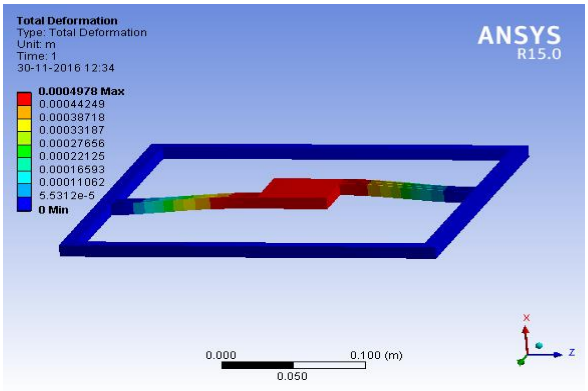

Fig.7 Deformation of Mechanism with three beam

4.2 Stress Intensity with 5 N force:

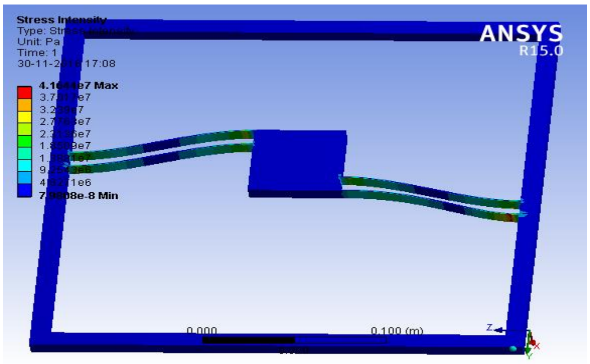

Fig.8 Stress intensity of Mechanism using two beams

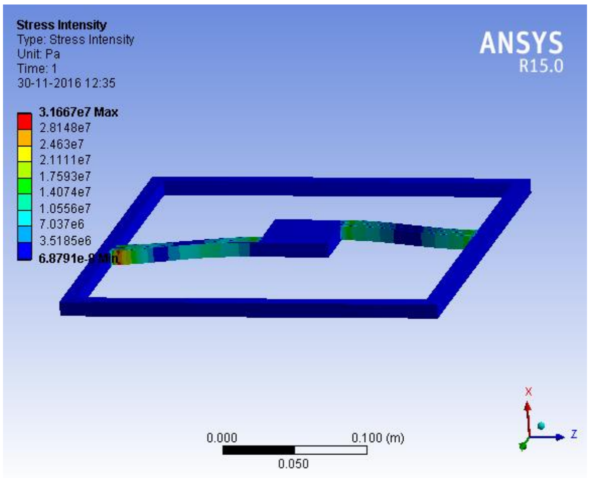

Fig.9 Stress intensity of Mechanism using three beams

Table-1: Displacement of Mechanism with respect to force and Linear Beam

Displacement with Two Beam (mm)	Displacement with Three Beam(mm)	Force in N
0.742	0.478	5
1.461	0.912	10
2.223	1.489	15
2.914	1.986	20
3.662	2.482	25

Table-2: Stiffness value of Mechanism with respect to force

Displacement with Two Beam (mm)	Displacement with Three Beam(mm)	Force in N
6.832	10	5
6.791	10	10
6.832	10	15
6.792	10	20
6.801	10	25

From Graph displacement of Mechanism increases with incremental load.

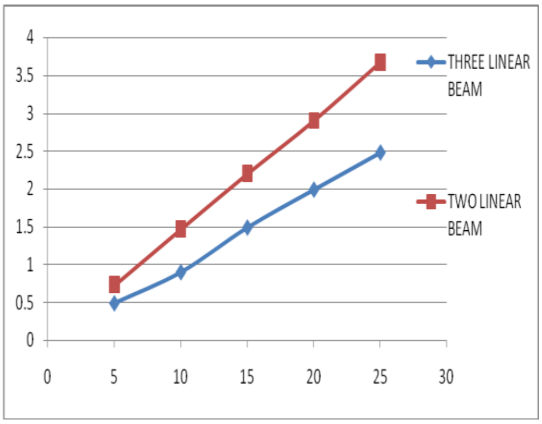

Fig.10Graph of Force vs displacement with linear force

4.3 Total Deformation after applying couple

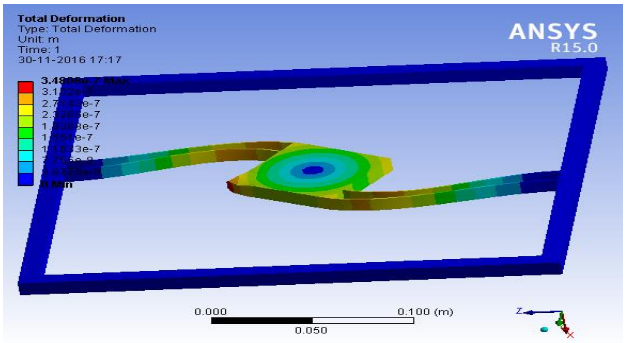

Fig.11 Angular Displacement of Mechanism with two beam

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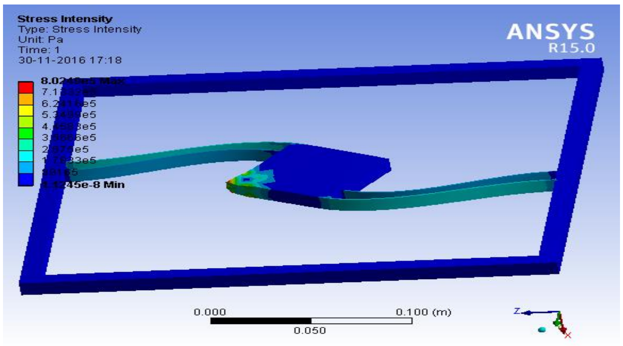

Fig.12 Angular Displacement of Mechanism with three beam

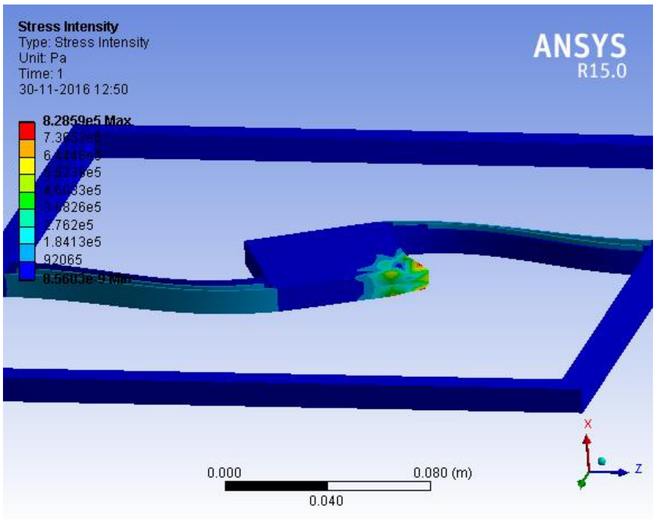

Fig.13 Stress intensity of Mechanism using two beams

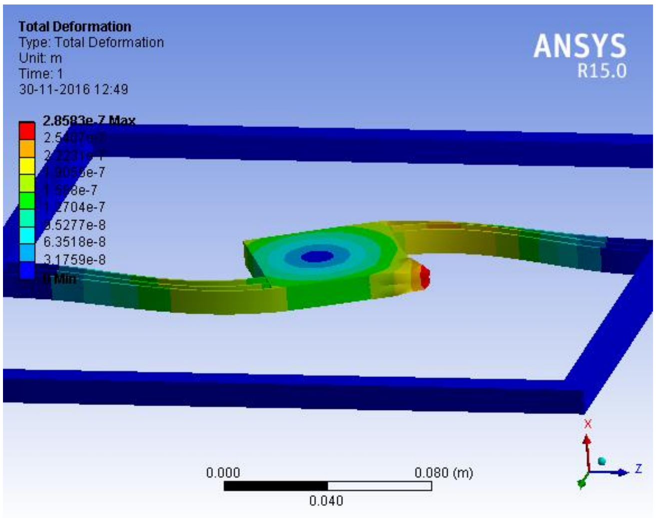

Fig.14 Stress intensity of Mechanism using three beams

Table-3 Displacement of Mechanism with respect to force and Curvilinear beam

Displacement with Three Beam (mm)	Displacement with Two Beam(mm)	Force In N
2.86e-7	3.488e-7	5
5.76e-7	6.985e-7	10
8.58e-7	1.045e-6	15
1.142e-6	1.392e-6	20
1.43e-6	1.745e-6	25

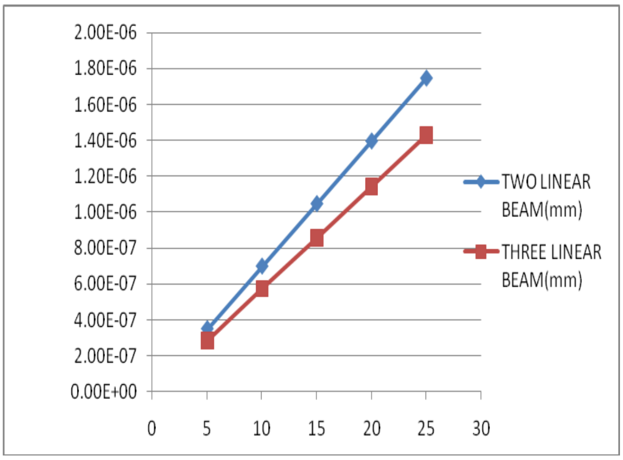

Fig.15 Graph of Force vs angular displacement

V. COMPLIANT MECHANISM WITH LINEAR MOTION IN ONE DIRECTION

Mechanism shows in fig.16 provides movement in X and Y direction as per actuation. Stainless steel material is selected for mechanism with thickness of 0.75mm and length of each strip is 50mm.

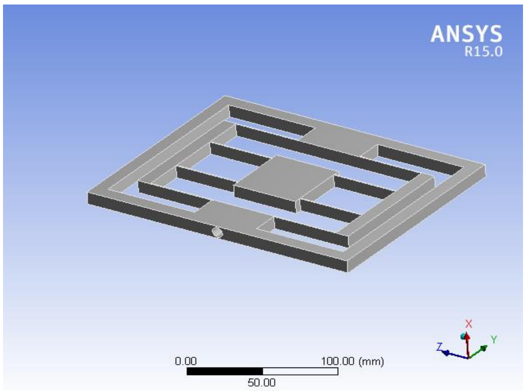

Fig.16 Double Compliant Manipulator in x-direction

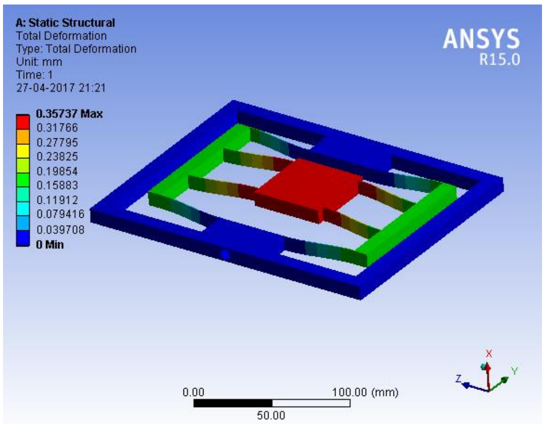

Fig.17 Deformation of Double Compliant manipulato

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Table-4: Displacement of Mechanism with respect to force

Intensity in Mpa	Displacement in Mpa	Force in N
32.171	0.35737	5
64.342	0.71474	10
96.514	1.0721	15
128.68	1.4295	20
160.86	1.7689	25

The stiffness of the beam comes out to be 5/0.35737=14N/mm

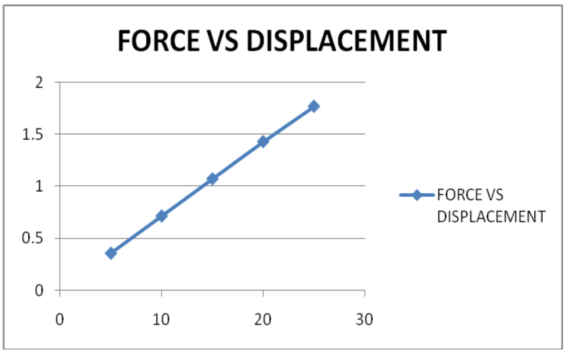

Fig.18 force vs displacement Double Compliant Manipulator

VI. CONCLUSION

- Entire Displacement of Compliant Mechanism is Evaluated with linear and .rotary beam for actuating force from 5N to 25N
- Compliant Mechanism with three linear beam shows stiffness of 10.1N/mm and with two linear beams gives stiffness of 6.842N/mm. The stiffness with DFM is 14.2N/mm. To achieve larger displacement by Compliant mechanism the material should have low stiffness value.
- As Effective length increases displacement of mechanism increases. Displacement value is maximum for mechanism with three beams as compared to mechanism with two beams since the effective length is increased.

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Sandesh Solepatil has received Masters of Engineering in Design from Pune University. Currently he is Pursuing Ph.d in Mechanical Engineering in Pmpri Chinchwad college of Engineering Pune. His area of Interest is Compliant Mechanism

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