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Design & Fabrication of Monolithic Complaint Peaucelliar Mechanism

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ABSTRACT

Monolithic compliant mechanism allows the transmission of force and motion viathe elastic deformation of the links and the change in the shape of the links temporarily when the load is applied. It is used in large areas where the applications of precision like the endoscopic tools which are being used in the medical treatments, sports, handicapped persons for running in marathons, large vehicles for abosorbing the shock waves etc. The intention of the project is to design and analysis of Peaucelliar mechanism for the straight line motion applications. The analysis of the mechanism is done by the Finite Element Analysis where the design is done through the Solid works to determine the straight line displacement and its stresses.

KEYWORDS: Complaint mechanism, force, motion, precession, endoscopic tools.

1. INTRODUCTION

The mechanisms when they give a straight line as output of the mechanism when the input of the mechanism is either the rotational motion or oscillating motions are known as straight line mechanism. The straight line mechanism is extremely helpful in the places like machinery design and manufacturing process to make a rectilinear motion, as the technology increases the usage of mechanism is also increases in the robotics field, therefore the straight line mechanism is also used in the roboticsfield [1]. Hart mechanism, Scott-Russel mechanism, Grasshopper mechanism, watt mechanism, Tchebicheff mechanism, kempe's mechanism, parallel linkages, Peaucelliar mechanism are all known as straight line mechanisms [2].

The Peaucelliar mechanism also known as Peaucelliar – Lipkin mechanism was first mechanism which was able to make a transformation from rotary motion to the linear motion and it is also the first true planar mechanism which was invented in 1864 and it was named after Charles-Nicolas Peaucelliar. At first this mechanism did not gain that much name until 1871. It was demonstrated independently by the Lipman Lipkin a Chevyshev pupil at the University of St. Petersburg [3]. The Peaucelliar mechanism generates the straight line and works on the principle of inversion. This principle is about the change in rotary motion to linear motion with geometrical constraints [4,5].

Complaint mechanisms are growing widely and rapidly in the modern world. The complaint mechanisms are joint less mechanism which makes them to look like a single entity. Complaint mechanism works by absorbing the strain energy and partial deformation of a body and gives the required motion. It transforms back to normal shape when the strain is released from the body. There are no linkages or joints between the links, because of

that the complaint mechanism has no friction. This mechanism is used where the friction is not required, wear resistance and the place where the precision is required. The Endoscopic tools are the example of complaint mechanism with precise movement which are used to treatment of patients by doctors. The complaint mechanism bends when the movement is given to the body. This requires a smooth handle for not breaking the mechanism at the bending areas. By comparing with conventional rigid mechanisms, the complaint ones have no or reduces backlash, friction, abrasion in mechanism [6,7]. The complaint mechanism does not make any noise; it is easier to maintenancewith better accuracy of movement [6,8]. At present days, the complaint mechanism is having the high focus by all over the over world and it has developed rapidly because of its advantages as required in modern technology used in machines.

Applications of complaint mechanism are [9]

- Bottle lid, binder clip, nail clipper, bag pack latch.
- Hand held tools like Complaint piler, gripper stapler.
- Bio-mechanics and Robotics.
- Electric and electronics.
- Micro Electro Mechanical Systems.
- Aerospace.
- Transportation.
- Medical tools.

2. REALATED WORK

Complaint mechanisms are the new type of mechanism which is developed by fabrication of the traditional mechanism. The complaint mechanisms are developing rapidly because of the research done on them and they are applicable to our daily type purposes to bio-medical technologies and robotics. Therefore, there are no. of researches done on the compliant mechanism are quietly more in the recent years.

This work is done based on the reference of fabricationof traditional Pantograph mechanism into the monolithic complaint pantograph mechanism. The monolithic complaint mechanism produces the straight line which is more applicable in industries applications. This work is about that the joints of the links which are attached between them arededuced and the curved structures are attached. By adding the curved structures to the links, the mechanism can give the accurate motion with more precision. They concluded that displacement synthesis has been presented for pantograph mechanism. The results based on FEA for the displacement and stress analysis of pantograph complaint mechanism withaluminum alloy 6601 and polypropylene materials were found safe for selected configurations.

3. PROPOSED WORK

In this paper, we are proposing a complaint Peaucelliar mechanism works as same as the traditional Peaucelliar mechanism but the difference is that unlike the joints in traditional mechanism, it is fabricated without the joints.

3.1 Peaucelliar Mechanism

A Peaucelliar mechanism is straight line mechanism which containsof 8 links. The given diagram is shown the Peaucelliar mechanism.

In the 8 links of the Peaucelliarmechanism, 6 of the links are same length and two remaining are the links are the longest links which are fixed with rotational joint at one end of the link.

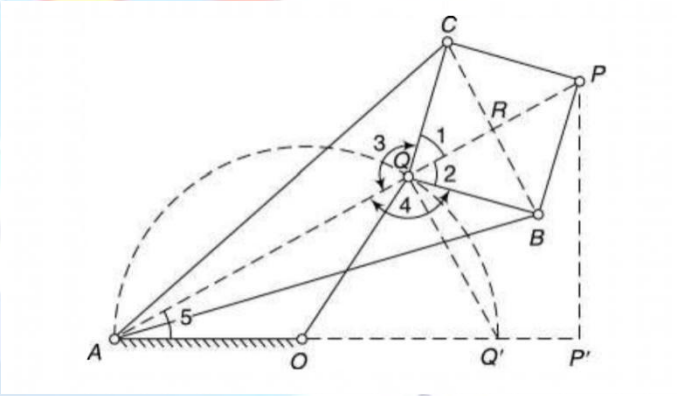

Fig.1 Peaucelliar Mechanism [2]

OA=OQ; AB=AC;

And BP=BC=CQ=QB

OA is the fixed link and OQ is a rotating link. It can be proved that as the link OQ moves around O, P moves in a straight line perpendicular to OA. The entire pin –Jointed.

Since BPCQ is a rhombus,

QP always bisects the angle BQC,

i.e.

$\angle 1 = \angle 2$ ……(G)

In all the positions

Also, in triangles AQC and AQB,

AQ is common,

AC= AB

QC=QB

Therefore, triangles are congruent in all positions.

Or $\angle 3 = \angle 4$ …… (E)

Adding (G) and (E)

$$\angle 1 + \angle 3 = \angle 2 + \angle 4$$

But $\angle 1 + \angle 2 + \angle 3 + \angle 4 = 360°$

$\therefore \angle 1 + \angle 3 = \angle 2 + \angle 3 = 180°$

Or A, Q and P lie on a straight line.

Let PP′ be the perpendicular on a AO produced

Triangles AQQ′ and APP′ are similar because 5 is common and angle AQQ′ = angle APP′ = 90°

…… (RP=RQ)

$\frac{AQ}{AP'} = \frac{AQ'}{AP}$

AQ′. AP′= (AQ)(AP)

= (AR-RQ) (AR+RP)

= (AR-RQ) (AR+RQ)

= $(AR)^2 - (RQ)^2$

= $[(AC)^2-(CR)^2]-[(CQ)^2-(CR)^2]$

$AP' = \frac{(AQ)^2 - (CQ)^2}{AQ'}$

AP′ = constant, as AC, CQ and AQ′ are always fixed.

This means that the projection of P and AQ produced is constant for all the configurations.

Thus, PP′ is always a normal to AO produced or P moves in a straight line perpendicular to AO [2].

3.2. Design of Peaucelliar Mechanism

The required design of Peaucelliar mechanism in the monolithic complaint mechanism type is prepared with help of SOLIDWORKS software.

For designing the Complaint Peaucelliarmechanism, The metal sheets are designed with the length of 100mm, width 25mm, and with thickness of 1mm. The metal sheets are taken up to 5 pieces, on those 5 pieces are the 4 pieces are arranged in a rhombus shape with internal angle of 45 degrees on the top side and bottom side of the rhombus. The sheets are attached with solid wire of length 5mm and with thickness of 1 mm. The other metal sheet was attached to the solid wire at the left side of the solid wire. There are two other metal sheets with same thickness and width, the length is considering as 30mm. The one side of the other two links is attached to the upper and lower sides of the metal wires. The other sides of the remaining two metal sheets are placed into the same line of axis which other link is attached to the rhombus to the left side. The other end of the longer link is fixed on the plane with a rotational joint. The other side of the link which is attached to the rhombus is a fixed one and it also a rotational joint. These two rotational joint is taken as bolt in the Solid works software. The result of the design of the complaint Peaucelliar mechanism is as done as shown in the below figure.

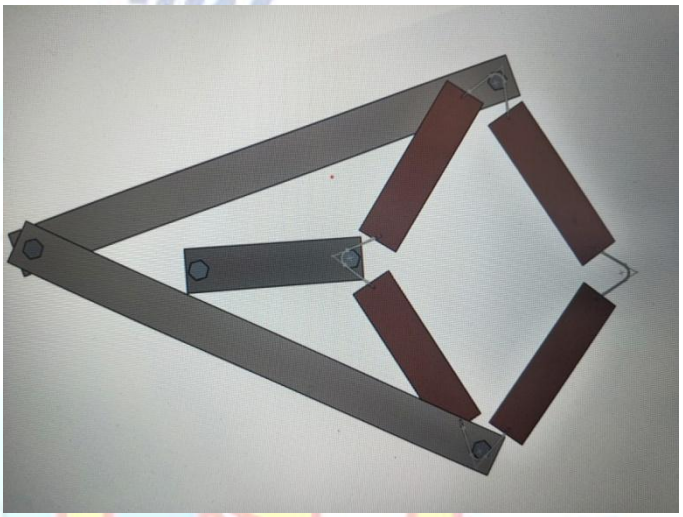

Fig.2 Design of monolithic complaint Peaucelliar mechanism

3.3 Analysis of complaintPeaucelliar mechanism

The analysis is done by using the Ansys workbench 15.O. The design which was done on solid works previously is transferred to the Ansys workbench by step format file. The geometric dimensions and constraints are fixed as the design from the solid works. Mesh is given to the body by 2 mm. The load is given in terms of moment. The moment applied here is 20N-mm. The material taken for the analysis of the Complaint Peaucelliar mechanism was structural steel. The structural steel has the properties which are good for making the fabricated piece in the Ansys software. The analysis is done with three various diameters of solid wire. The diameters chosen for accomplishing the mechanism were 0.8 mm, 1.0 mm, 1.2 mm. Here the analysis is shown for the dia 0.8 mm.

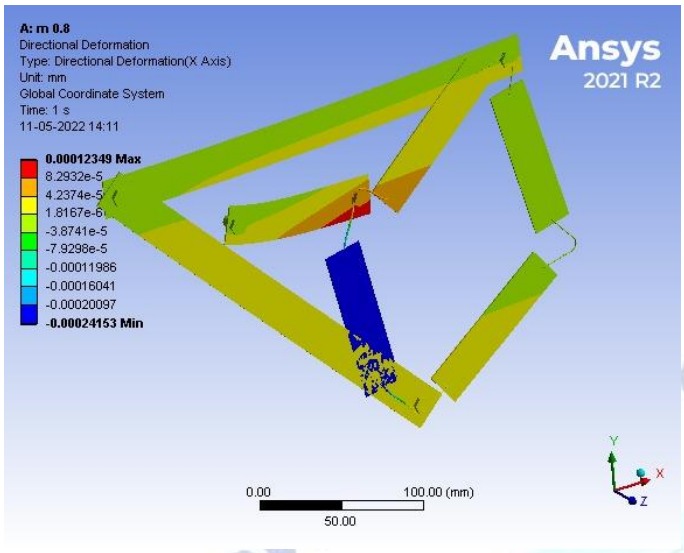

Fig.3: Directional deformation (x axis)for dia. 0.8 mm

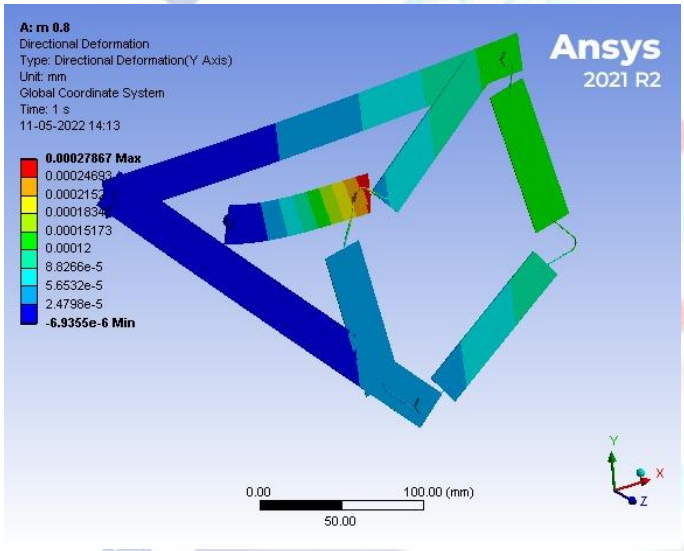

Fig. 4:Directional deformation (y- axis) for dia. 0.8 mm

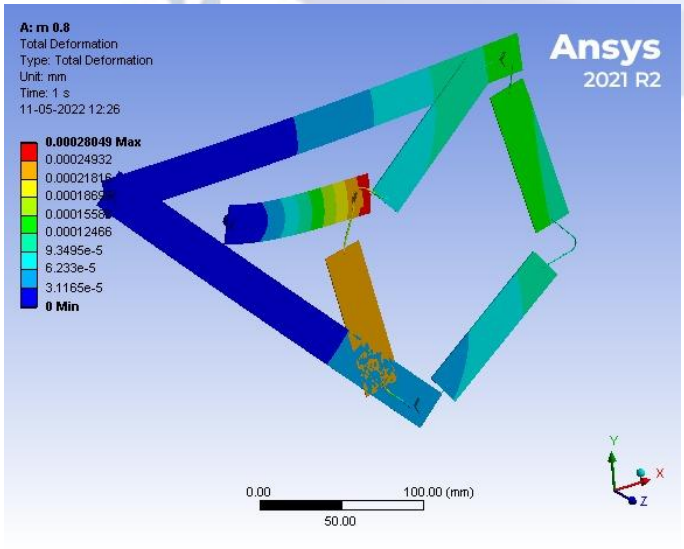

Fig. 5: Total deformationfor dia. 0.8 mm

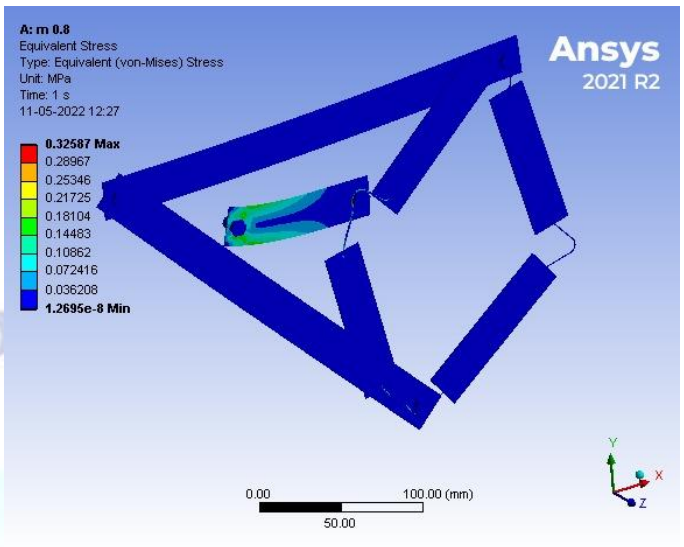

Fig.6: Equivalent stressfor dia. 0.8 mm

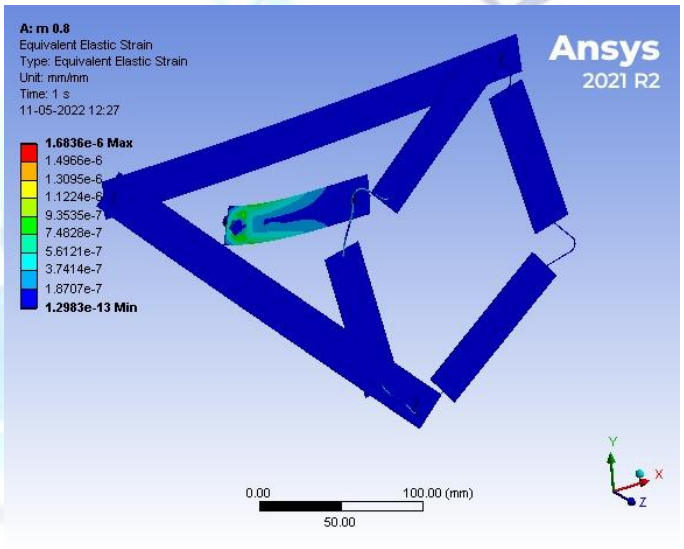

Fig.7: Equivalent elastic strainfor dia. 0.8 mm

3.4 Fabrication of Peaucelliar mechanism

The fabrication of Peaucelliar mechanism is done using the metal sheets, metal wires and bolt and nuts. The metal sheet with 1mm thickness is taken andit is shaped into rectangular shape with 100mm length and 25 mm width. The no. of sheets is shaped into same dimensions are 5. Cut the other two rectangular shapes with length of 300mm and width of 25mm. The metal sheets are attached by the metal wires with thickness of 1mm and length of 50mm. These metal wires are attached by the spot welding which was done smoothly and gently. If the load applied is more when pressing the spot welding machine,the wire will be broken. The metal

sheets with 100mm length are arranged in the rhombus shape and are attached with metal wire. The angle between the two metal sheets by attaching with the metal wire at top and bottom sheets are 45 degrees which is same given in the design of mechanism. The remaining sides of rhombus are attached which are adjustably to the rhombus. The other metal sheet is attached to the upside if the left side of metal wire which is attached to the rhombus. The other end of the fifth metal sheet is fixed with rotational joint. The one end of two long sheets is attached to the top and bottom metal wires which are attached to the rhombus. The other end of the two long sheets is fixed with rotational joint with in same line of the previous fixed joint.

4. RESULTS

In this session, we are giving the results of our project. The fabrication of traditional Peaucelliar mechanism into the monolithic complaint mechanism is done. The fabricated mechanism is working and it gives the straight line as output when the given input is in rotary motion. The joints are deduced into small curved beam which the strain energy is stored when the load is given and elastic deformation is done to the fabricated piece. When the given load is taken out from the fabricated piece the strain energy which is stored at the curved beam is released and changes into normal shape of the mechanism.Finite element analysis results for a moment of 20 Nmm are as given below for various wire diameters.

Table. 1- for dia. 1mm

S.no.	Type of deformation	Maximum value	Minimum value
1	Directional deformation (x-axis)	0.00013219 mm	-0.0001698 mm
2	Directional deformation (y-axis)	0.00027301 mm	-7.1677e^-6 mm
3	Total deformation	0.00027642 mm	0 mm
4	Equivalent elastic strain	1.5463e^{-6} mm/mm	6.5236e^{-13} mm/mm
5	Equivalent stress (von-mises)	0.230513MPa	3.6859e-^{18} MPa

Table. 2 – For dia. 0.8 mm

S.no	Type of deformation	Maximum value	Minimum value
1	Directional deformation (x-axis)	0.00012349 mm	0.00012349 mm
2	Directional deformation (y-axis)	0.00027867 mm	-6.9355e^{-6} mm
3	Total deformation	0.00028049 mm	0 mm
4	Equivalent elastic strain	1.6836e^{-6} mm/mm	1.2983e^{-13} mm/mm
5	Equivalent stress (von-mises)	0.32587 MPa	1.2695e^{-8} MPa

Table. 3- For dia. 1.2 mm

S.no	Type of deformation	Maximum value	Minimum value
1	Directional deformation (x-axis)	0.00012035 mm	-4.8147e^{-5} mm
2	Directional deformation (y-axis)	0.00033074 mm	-6.59756^{-6}
3	Total deformation	0.000276420 mm	0 mm
4	Equivalent elastic strain	1.2736e-6 mm/mm	1.83776e-6 mm/mm
5	Equivalent stress (von-mises)	0.21993 MPa	3.0853e-7MPa

5. CONCLUSION

In this paper, we suggested a monolith complaint Peaucelliar mechanism that is fabricated by removing the joints of the traditional Peaucelliar mechanism and added the curved structured metal wires which are helpful to store the strain energy and temporarily deformation of the fabricated piece when the load is applied. The usage of complaint mechanism is high in the modern technology. The complaint mechanism is like a single entity of the body where it reduces the usage of bolt and nuts and reduces the friction wear, reduces noise, using of lubricants in the joints, attaching the joints

when they broke because of some accidents. By using the monolithic complaint Peaucelliar mechanism we can reduce the no. of joints to be attached and it increases the precision movement of the mechanism which gives the straight line motion when the rotary motion is given initial input motion of the mechanism.

Conflict of interest statement

Authors declare that they do not have any conflict of interest.

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