

## Design of Ergonomic Comfort Chair

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**Abstract-** For many people rising from a seating position can be a painful experience due to the inflammation of their joints. To overcome this problem, we have designed a chair that supports a person while sitting down as well as standing up without using any external power source. The design of the chair is based on 2 port bi-stable compliant mechanism. Bi-stable mechanism are mechanism with 2 stable state and only require force to actuate between these states. The chair is ergonomically designed such that it is comfortable and reduces the stress on the person's knee while standing on sitting. The chair design of the chair is modelled in Solid works for better graphical representation.

**Key Words:** Compliant Mechanism, Comfort Chair, Bi-stable Mechanism, Tin-lid Mechanism.

### 1. INTRODUCTION

As humanity strive to improve their living condition through various methods, they started to ignore their health. Large population of the world has started to suffer from back and knee pain since their young years. Many people don't have proper body posture while sitting. Slowly it reaches the point of agonizing pain and in some cases, it increases to such a degree that even painkillers are ineffective. Some elderly people are unable to sit or stand up without any support, this has a negative influence on their daily life. The solution to this problem can be in the form of an "comfort chair". But comfort chairs found on the market are expensive and are based on actuators and complex pneumatic. They require external electrical energy. Which is not readily available in many developing countries such as India. Thus, there is a need for a comfort chair based on an energy concept that does not require electric energy.

So, we decided to build a comfort chair that will be affordable and durable. This comfort chair will be based on the bi-stable compliant mechanism

#### A. What is a Comfort Chair?

A comfort chair is a large, comfortable chair, typically an armchair. As humans started to secure their necessities easily, they started to focus on other luxurious products to make their life comfortably one such product is the comfort chair. So basically, it is a chair designed for the people who need to sit in one place for long hours for their work or in daily life.

To perform various activities. Our comfort chair is a chair that supports a person to stand from a seated position. It does this by gently pushing a person towards the standing position. It also reduces the stress on the knee while sitting down by reducing the jerk by giving gentle support. It is particularly aimed at people who have conditions that lead to inflamed joints. These people have difficulty to stand from a seated position. The comfort chair gently pushes the person who is sitting on it to a standing position when they want to stand. Thus, being of great help particularly to older people.

#### B. Targeted Customer Base

In this world, many diseases result in a person suffering from back pain or unable to sit for long hours such as Rheumatoid Arthritis, Bursitis, Avascular necrosis, diffuse idiopathic skeletal hyperostosis and many more [1]. And the approximate population affected by this is huge. As well as there are many more people looking for a comfortable chair to sit, especially people working in the field such as the IT industry need to work in the cramped work space. To avoid the health problem, they need the comfort chair. At the same time, some like to spend their free time in front of the television and it was found that most people while watching TV always keep bad posture and this chair is also aimed for the elderly people who have trouble sitting as well as getting up from the chair and need support to do so. It is also for the people who are in the kind of job they have contentiously sit and get-up at rapid intervals.

### C. What is a Compliant Mechanism and Why?

A compliant mechanism can be defined as a single piece of the flexibility of its members rather than from rigid-body joints alone. Such a mechanism, with built-in flexible segments, is simpler and replaces multiple rigid parts, pin joints, and add-on springs [2]. Hence, it can often save space and reduce the costs of parts, materials, and assembly labor. Other possible benefits of designing compliance into devices may be reductions in weight, friction, noise, wear, backlash, and important maintenance. There are many familiar examples of compliant mechanisms designed in a single piece that replaced rigid link mechanisms [3].

We can simply manufacture a single-piece fully compliant mechanism via injection molding, extrusion and rapid proto-typing for medium size devices, or using silicon surface micro machining and electroplating techniques for compliant micro-mechanisms [4]. Although a compliant mechanism gives multiple advantages, it is difficult to design and analyze. Most of the current compliant mechanism design, however, must be performed without the aid of a formal synthesis method and is based on the intuition and experience of designers. Several trials and error iterations using finite element models are often required to obtain the desired mechanical performance.

So, it can be summarized as complaint mechanism have longer life highly flexible comfort to mass-produce and have better compactness that general rigid as well as tradition mechanism and the best part it is that this mechanism is highly energy efficient

## 2. PROBLEM STATEMENT

For many people sitting as well as rising from a seated position can be a painful experience due to inflammation of their joints. While there are several existing chairs designed to address this problem, most use electrical actuators or complex hydraulic systems. Since electrical power is not available everywhere for the entire day, especially in developing countries, there is a need for a comfort-chair that gives support during rising from the chair without using external by changing from lower to upper stable state.

## 3. METHODOLOGY

As there are various type chairs are designed for a person who works form the same sitting position long time to increase their productivity and to reduce low back injuries. The easy chair work on a bi-stable statically balanced mechanism to solve this problem without using any external power. The main mechanism of the easy chair is below the seating platform. There is a pre-compressed metal strip in the buckled form attached to pinned - pinned ends. The strip is made up of Alloy steel. As the strip follows the bi-stable mechanism, so when a person sits on a chair the strip changes position from upper to lower stable state without giving any bumping effect to the body. This lower state helps the person to relax the body. During design comfort of the seat, backrest, hand rest, and legs are considered. For rising from the lower stable position, the mechanism is triggered by applying slight force on the chair arms by arms and strip of the chair helps the person to rise up by changing from lower to upper stable state. Due to this person can easily rise from the chair without taking any load on the body stable mechanism. The chair is designed to gently propel from a seated position. The chair has 2 stage states 1<sup>st</sup> when the seat is in an inclined position and position 2<sup>nd</sup> when the seat is in horizontal position.

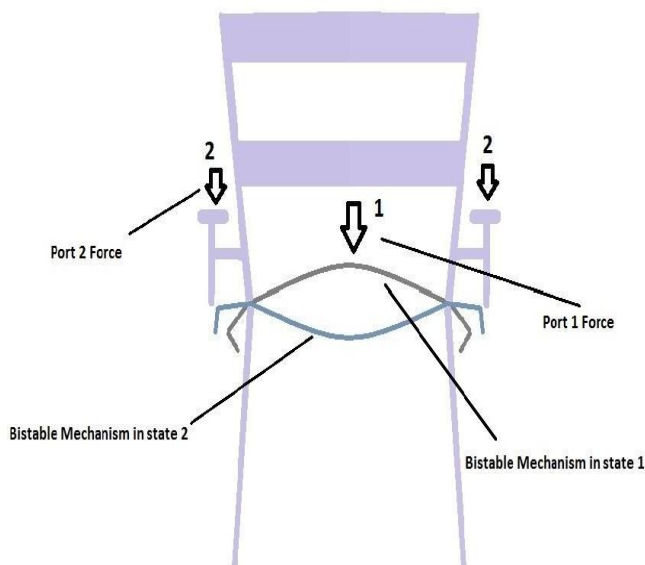
## 4. DESIGN

### 4.1. Customer Requirement

To satisfy and heighten the customer satisfaction we designed the comfort chair while analyzing the following factors.

**Table:1**-Consumer Requirement Chart

Customer Needs	
Customer Request	Requirements
It should be safe to get in and get out (should not slide back).	Safety
The seat should be comfortable to sit in for a long duration.	Comfort
Should assist in rising	Ease of Egress/Gettin g up
Should be adjustable in terms of weight of the person, back support, etc.	Adjustability
Should be attractive	Aesthetics
Should be affordable to the lower middle class	Affordability
Should be comfort to manually move around	Portability
Should have a life that is com- parable to a standard chair.	Durable

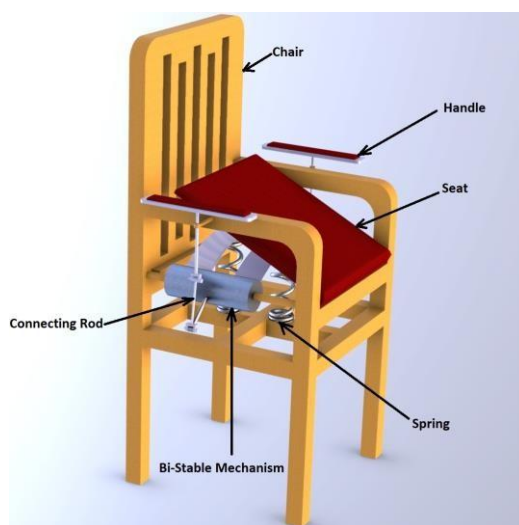


**Fig-1:**Basic Design

When the seat is in inclined position the weight of the person sitting on the seat acts at the 1st port of the mechanism thus the mechanism actuates to the 2nd positions. When the person sitting wants to stand the arm of the chair acts as 2nd port of the mechanism. Thus, actuating the mechanism to the first position as well as propelling the person towards the standing position [5].

## 4.2. Final Design

This design consists of a basic chair model with a few modifications for providing guideways and support to the mechanism. The seat is a part with a hinge provided in the front. This hinge is inserted into the hole provided in the chair this enables the seat to be raised and rotated along the hinge. The bi-stable mechanism is placed under the seat. The mechanism is inserted into the hinge provided in the chair. The handle shafts are inserted into the guides provided in the chair. The guides constrain the motion of the handle to one direction. The connecting rod connects the mechanism to the handle converting the rotary motion of the mechanism into linear motion.



**Fig-2:** Final Design

When a person sits on the chair the mechanism will actuate from the first state to the second state. This also raises the handle. When the person wants to get up, he presses the handle downward. This exerts a force on the mechanism actuating it back to the first state as well as pushing the person out of the chair into a standing position. Springs are provided so that the amount of force that needs to be exerted on the handle can be reduced. The spring stores energy when the person is sitting. It also prevents the jerk when the mechanism is transitioning from the first state to the second state.

## 4.3. Essential Parts of comfort Chair

### 4.3.1 Connecting Rod

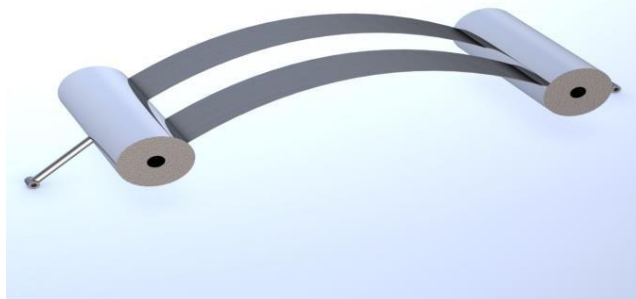
The rod on the bi-stable mechanism makes a rotary motion when it moves from one state to another. But the handle can only move in a linear motion. The connecting rod acts the same way as a connecting rod in a single slider mechanism converting the rotary motion into linear motion. It is made of steel.



**Fig-3:** Connecting Rod

#### 4.3.2. Bi-stable Mechanism

The bi-stable mechanism is a mechanism with two points of stability and requires an external force to move from one point of stability to another. This mechanism consists of two parts, a cylindrical part with two slots for the bi-stable strips and two pre-stressed strips. The strips are made of alloy spring steel and the cylindrical holder is made of mild steel.



**Fig-4:** Bi-stable Mechanism

#### 4.3.3. Spring

Spring is an elastic object which stocks mechanical energy. In this mechanism, coil springs are used. When a person sits on the chair the displacement caused is stored as mechanical energy in the spring. This also prevents a jerking when the person is sitting as the spring will slow down the motion of the seat towards the horizontal position. The stored energy is used later when the seat is being raised thereby reducing the amount of force that needs to be exerted on the handle of the mechanism. The spring should be designed such that it provides enough force to assist in raising the seat but the force should not be so great that it triggers the mechanism by itself since that would make the bi-stability of the mechanism redundant.



**Fig-5:** Spring

#### 4.3.4. Basic Chair Model

The chair serves as the part main body which holds the entire mechanism collectively. This basic chair model has been modified to use a bi-stable mechanism. A hinge is provided on the chair for the mechanism. This hinge ultimately carries the entire force that is exerted on the mechanism. Guide ways are provided along the arm of the chair to support the arm of the mechanism. A horizontal base is also provided to support the spring. A slot is provided for the hinge part of the seat as well as a horizontal extrusion to support the seat in a horizontal position.



**Fig:6**-Basic Chair Model

#### 4.3.5. Seat

The seat is the part on which the user will sit. It needs to have both functionalities as well as comfort. The seat needs to be able to move between a horizontal position and an inclined position. Thus, a metal sheet with a hinge at the end is used. The metal sheet needs to be strong enough to carry the weight of the person without any deformation. The hinge is inserted into the slot provided on the chair that lets the seat rotate along the axis of the hinge. A cushion is also provided so that people can sit on it comfortably for a long duration.



**Fig: 7**-Seat



**Fig:8**-Handle

The handle consists of a metal plate that is welded to a rod which has tapped on the other end. The rod is passed through the guiding structure of the chair which allows motion only in a single direction. Cushions are provided on the metal plates for better comfort.

#### 4.4. Material Selection

While considering the various requirement for bi-stable mechanism we shortlisted with two different material we can use they are as follows.

Material Comparison		
Properties	Alloy spring steel	Titanium Grade 2
Density	7.86g/cm <sup>3</sup>	4.5 g/cm <sup>3</sup>
Tensile Strength	220 GPa	344 GPa
Maximum operating temperature	246°C	426.667°C
Elastic modulus	125.5 GPa	105 GPa
Price	Rs170/Kg	Rs1200/Kg

**Table:2**-Material Selection

Although the Titanium grade 2 is more suitable for compliant bi-stable mechanism due to its superior mechanical properties, due to its high cost it is preferred to use alloy spring steel. Although alloy spring steel is comparably cheap and has a good factor of safety. But the lifetime of mechanism and the smoothness of bi-stability behavior only go to tolerable limits. This condition has to be compromised. The advantage of allotting spring steel lies in the fact that it is easily available and is considered as one of the great materials for mass production.

The suitable material for the basic chair model is customized as per the customer demand. The preferable materials are wood, metal, or other strong materials, like stone or Acrylic, Wicker. As for the regular mass-production Fiberglass or Polypropylene/MouldedPlastic should be favorable.

The handle is the part that the user uses to actuate the mechanism. The force that is exerted on the arm gets transferred to the mechanism through the connecting rod. The handle only moves linearly. The guiding structure on the chair helps to guide this motion.

Cushions for the seat are fashioned from polyurethane foam, polyester fiber, down, cotton, latex, or cotton-wrapped springs.

For the spring and single slider mechanism we selected are high carbon, alloy steel, and stainless-steel wires.

## 5. WORKING

Two Port Bi-stable Mechanism is Bi-stable mechanisms have two stable equilibrium positions. The energy level is low at both of the two stable positions. There is an unstable equilibrium position that has a high energy level between the two stable equilibrium positions. Power input is not needed for bi-stable mechanisms to maintain any of their two stable positions. Actuation is only necessary to switch from one stable position to another. Because of the high energy in-stable equilibrium position, a bi-stable mechanism will resist itself away from its stable equilibrium position under a certain amount of external disturbance. When a bi-stable mechanism is actuated and driven away from one stable position, it snaps to another stable position from the unstable equilibrium position.

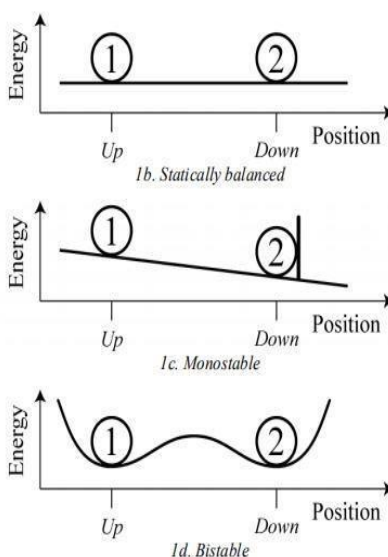


Fig:9-Energy vs Position [5]

The bi-stable mechanism is a mechanism with two stable equilibrium positions. In most planar bi-stable mechanisms, the point and line of action of the actuation forces to switch from state 1 to state 2 is the same as that from state 2 to state

1. In other words, they are “single- port bi-stable mechanisms. For e.g., in switch, the line of action for actuation between on and off state is the same.

Bi-stable mechanism with two different ports for actuation is called a 2-port bi-stable mechanism, for example, the click-clack tin lid mechanism. Consider the click-clack tin-lid mechanism. The diagram shows how it can be switched between its two stable states. It has two force-free stable states (i.e., bi-stable) and it can be operated at the two ports. The easy chair is also based on similar principals.

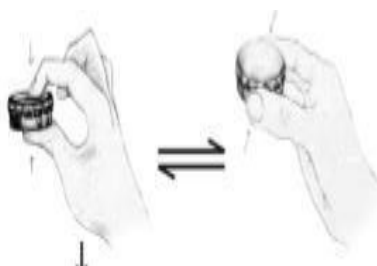


Fig:10-Click-Clack Tin-lid Mechanism [5]

## 6. MECHANISM

The mechanism is initially in the first state pushing the seat to an inclined position. When a person sits on the chair the force is applied on the mechanism on its first port. When this force is greater than a critical limit the mechanism will actuate towards the second state and the seat will be in a horizontal position. To prevent a jerk motion when moving from the first state to second spring are positioned below the bi-stable strips. This ensures a gradual motion when going from standing to sitting position because spring provides a resisting force as well as storing energy for later use. This reduces the stress on the knee while sitting by making it a gradual motion.

When the person wants to stand, he will push the handle of the mechanism downwards while trying to stand. The force applied by the handle will actuate the mechanism on its second port. This force will be supplemented by the force of the



spring. The spring stores the energy when the person is sitting and reduces the force that needs to be applied on the handle to actuate from state 2 to state 1. Thus, when the combination of forces applied on the handle as well as the spring force becomes equal to critical force the mechanism will actuate supporting the person to move into a standing position. The mechanism may carry 40% to 60% of the weight of the person thus greatly reducing the stress on the knee of the person.

## 7. CONCLUSION

We have designed a chair that can be a great help to people who suffer due to knee pain while sitting or getting up from a chair. Using this chair will result in reduced stress acting on the knee which will reduce knee pain in the long term. We have designed a chair that is easy to manufacture, has low cost and is also highly customizable according to user requirement. Thus, we believe that it is a technology that could be highly useful to a large portion of the population.

## 8. FUTURE SCOPE

The comfort level can be improved by selecting proper compliant material with a combination of different material which has required material properties based on young's modulus and harmonic analysis. That results in lower vibration during actuation. This proposed chair can be updated with additional functionalities such as fitted with wheels to its legs for easy movement from one place to another, the back post of the chair can be converted into adjustable so that each and every person can adjust the back post by according to their comfort, height of the chair is customizable to facilitate the users with higher comfort and additional functional needs to the user

## ACKNOWLEDGEMENT

We have immense pleasure in successful completion of this work titled "Comfort Chair Based on Bi-Stability Of Pre-compressed Strip". The special environment at Bharati Vidyapeeth College of Engineering that always supports educational activities facilitated our work on this project, special thanks to our principal. We acknowledge the support, guidance and encouragement extended for this project by our Project Coordinator of Mechanical Department Prof.A.S. Bongade and Project guide Prof. Jaydeep Patil who responded promptly and enthusiastically to our requests, despite of congested schedules.

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