DESIGN AND MODELLING OF HEIGHT-ADJUSTABLE GRAB HOLDER

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Abstract - *This paper deals with the design as well as analysis of a height-adjustable grab holder. The concept is to reduce the human effort while traveling in buses. The height of the grab holder can be adjusted with the help of a switch so that the passenger can adjust the holder to his/her comfortable height.*

The conventional grab holders currently available in the market are for passengers having an average height. Since most of the passengers are either shorter or longer than the average height, they have to go through some trouble while holding it. But on the other hand, our design helps the passenger to manually adjust the height and thereby making them comfortable throughout their journey.

Key Words*: *Height-adjustable, Grab holder, Switch, Public Transport, Spiral Spring, Helical Spring

1. INTRODUCTION

Buses are nowadays an indispensable part of one's life due to the hike in fuel price and the comfort for long journeys. Among the different features in a bus, the most important element is the grab holder. A grab holder is a safety device that is used to provide the passengers with a holding grip while standing in a moving bus.

Even though many grab holders are currently available in the market, they are neither efficient nor comfortable for the passengers. The major problems with these types of grab holders are their continuous movement and fixed height. This ineffectiveness can lead to serious injuries while sudden braking occurs. All the conventional grab holders are made for passengers with average height while every other passenger has to adjust to this height and go on an unpleasant journey. All this inspired us to bring a new design to overcome the downside of these conventional holders.

A grab holder is fixed on top of the bus and whose height can be adjusted depending upon the will of the passengers. That is if a short person is using this holder, he/she can increase the height by simply pressing a switch that is available on the grab holder to unlock a roller that is present inside it and then by pulling the holder downwards. On releasing the switch, the roller is locked and the height is adjusted to the passenger's desire making their journey more comfortable. To avoid continuous movements, our grab holder is fixed to the top handrails which prevent any possible injury due to the skidding of the holder while braking. So, our design not only provides the passengers a comfortable journey but also a safe one.

Hitherto, no such methods relating to the adjustment of holders in public transport according to the convenience of availing passengers have been reported. This paper presents a novel method to incorporate such a promising design into the grab holders currently being used in public transport.

2. PROBLEM STATEMENT

One among the many problems faced by the passengers availing public transport every day in our country will be the limited number of seats available for them during the journey. This forces a considerable number of the passengers to remain standing during their ride. Staying on your feet for hours while on a moving bus can be very much tiresome and exhausting. Also, it is not safe. The only support available to such standing passengers is the hand-holders dangling above their heads. A hand holder is also not much of rigid support to lean on but comes with its limitations and problems. Some of the problems of current hand-holders include:

[1] Continuous movement of the hand-holder with the movement of the vehicle.
[2] Non-adjustable length of the holder.
[3] Comfort of the material used for its manufacture.

By our design in this paper, we are aiming to tackle the limitation of the height of the current holders by making it easier for the passengers to adjust its length according to their convenience.

3. PROJECT OBJECTIVE

The main aim of our project is to design a completely new grab holder which can be used comfortably by anyone irrespective of their height. This can be achieved by adjusting the holder's length according to the passengers' will. The holder is also fixed at the top so that there is no continuous movement while the bus is in motion. The main objectives of our design are:

[1] To be used comfortably by anyone irrespective of their height.
[2] To get a proper balance to the standing passengers.
[3] Should be simple and user-friendly.

[4] To improved sustainability by using less plastic.

4. DESIGNING AND WORKING

4.1 DESIGN

4.1.1 Spiral spring

The spring is wound by rotating the arbor. During the winding process, energy is stored in the spring. This energy is released as the mechanical torque of the system. When it gradually rotates, this torque is released through the drum and the spring unwinds.

Fig -1: Spiral Spring (CAD Model)

4.1.2 Drum

The drum houses a spiral spring in it and lengths of nylon strip are wound around it. The material used for its manufacture is Carbon steel AISI 1080.

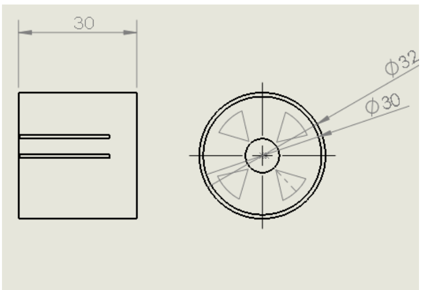

Fig -2: Top & Front views of Drum

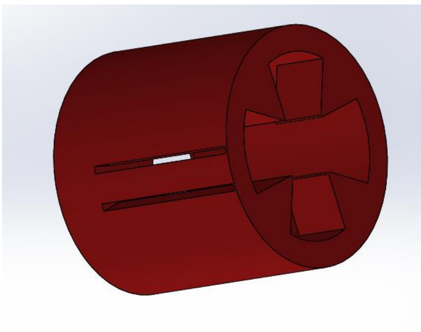

Fig -3: Design of Drum (CAD Model)

4.1.3 Button

The button with a helical spring in it restricts the free rotation of the drum. It is manufactured with the same material as that of the drum.

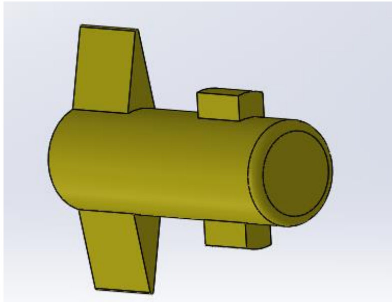

Fig -4: Button (CAD Model)

4.1.4 Helical spring

We are using a spring-loaded button.

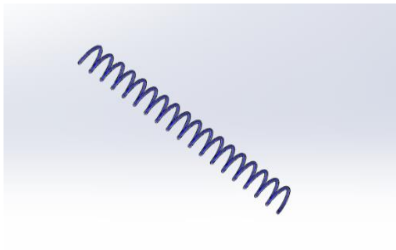

Fig -5: Helical Spring (CAD Model)

4.2 DESIGN CALCULATIONS

4.2.1 Selection of Spiral spring

Diameter of spiral spring (2r) = 30mm

Assuming a maximum weight of 1kg acting on the holder,

Maximum Torque assumed(M) = $F * r$ *= 150 Nmm*

(1G Force)

Bending stress = $\sigma = M * \frac{y}{I}$

Width of the strip(b) = 4mm

Bending stress (B) = 800 $\frac{N}{mm^2}$

Average maximum solid stress in Carbon steel spring of thickness is 1200 Pa from the below graph.

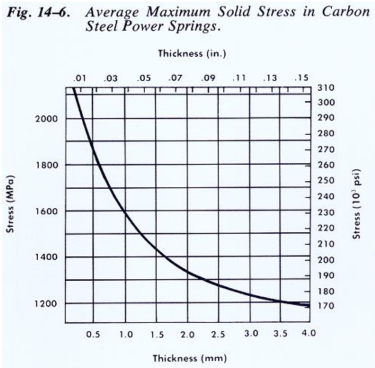

Chart -1: Average Maximum Solid Stress in Carbon Steel Power Springs

Thickness of strip (t^2) = $12 * \frac{M}{b*B}$

t = 0.75 mm

Da = Arbor diameter = 6 mm
Dc = Case diameter = 30 mm

Length of the strip = $\frac{Dc^2 - Da^2}{2.55 * t}$

Length = 452mm = 0.452 m

All calculations & chart based on *"Design Handbook: Engineering guide to Spring Design", Assn. of Spring Barnes Group Inc.*

4.2.2 Selection of helical spring

Assuming a Force of 2 N acting on the button to produce a deflection of 5 mm,

Spring Index(C) = 8,

Material: C-35(Carbon steel)

Yield Strength = 1100 N/mm^2

Shear stress = 690 N/mm^2

Rigidity Modulus(G)= 78.45 KPa.

Spring Constant(K) = F/X = 0.4N/mm

Shear stress factor = $1 + \left(\frac{1}{2} * C\right)$ *= 1.0625*

Resultant Shear stress = 690 = $\frac{8*W*D*Ks}{\Pi*d^3}$

Wire diameter(d) = 0.25mm

Therefore, Coil diameter(D)=2mm

Deflection = $\frac{8*W*D^3*n}{G*d}$

Therefore, n = number of active coils = 12

All calculations based on *"Design of Machine elements" by V.B. Bhandari, The McGraw Hill Companies Delhi, Second edition, 2007.*

4.3 WORKING

The conventional grab holder is for a passenger having an average height. Since most of the passengers are either shorter or longer than this average height, most of them are unpleasant with the current grab holders. To solve this problem, we have come up with a height-adjustable grab holder.

The height of our holder can be adjusted by pressing the button on a side of the holder and then adjusting the holder to a comfortable length. When the button is pressed and the holder is pulled, the drum housing a spiral spring inside the holder will be able to rotate causing the spiral spring to produce torsional energy. Then the nylon strip wounded around the drum will also rotate and thereby increases the length of the holder. When the button is released the free movement of the drum stops. The button acts as a lock. By doing this, the passenger can adjust the height to his/her comfortable holding position.

The spiral spring will always tend to return to its initial position due to the restoring torque that is generated on it due to the rotation.

5. STRUCTURAL ANALYSIS

5.1 Button analysis data

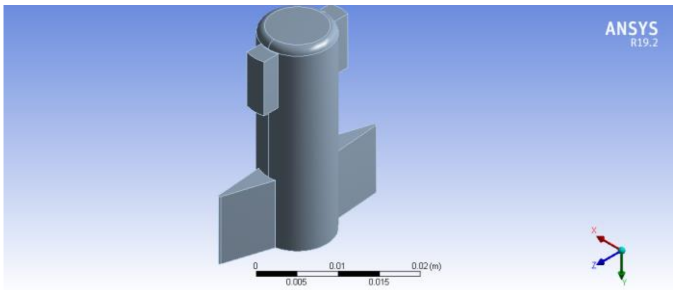

Fig -6: Button part Design Model

Equivalent stress under 600 N force
Maximum = 0.145 GPa

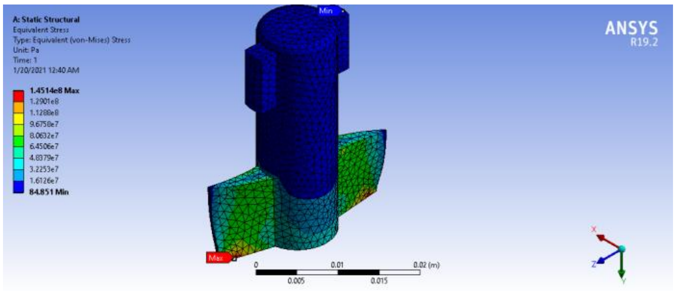

Fig -7: Button Part Equivalent Stress Data

Safety Factor under 600 N force
Minimum factor of safety = 4.0307

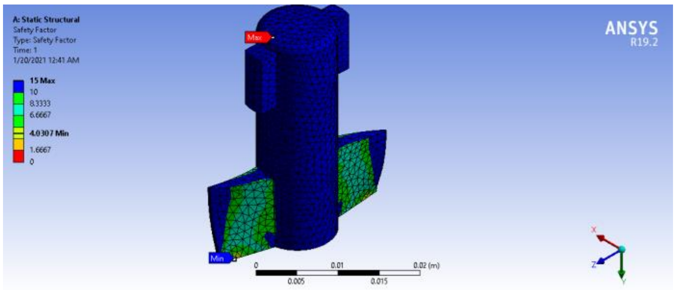

Fig -8: Button Safety Factor Data

5.2 Spring Cavity analysis data:

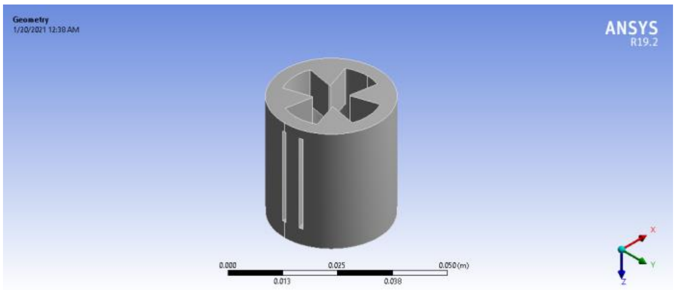

Fig -9: Drum Design Model

Equivalent stress under 600 N force
Maximum = 0.115 GPa

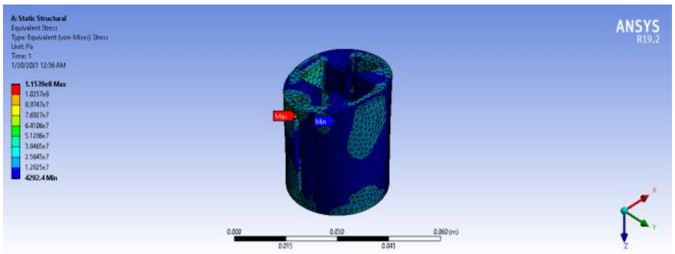

Fig -10: Drum Equivalent stress Data

Safety Factor under 600 N force
Minimum FOS = 5.0699

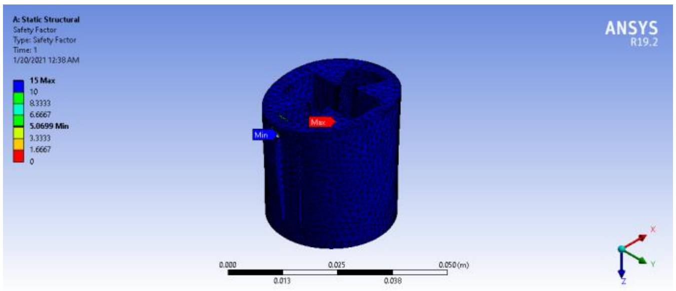

Fig -11: Drum Safety factor Data

5.3 Grab Holder Body analysis data:

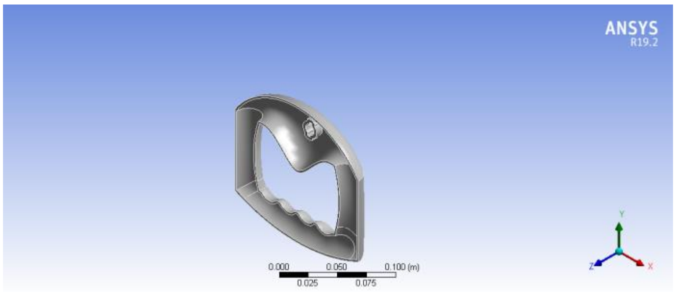

Fig -12: Holder Design Model

Equivalent stress under 600 N force
Maximum = 0.0471 GPa

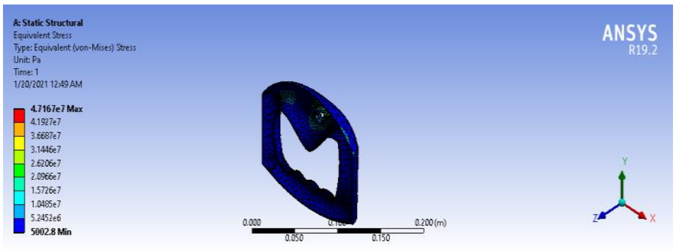

Fig -13: Holder Equivalent Stress Data

Safety Factor under 600 N force
Minimum Factor of safety = 5.1519

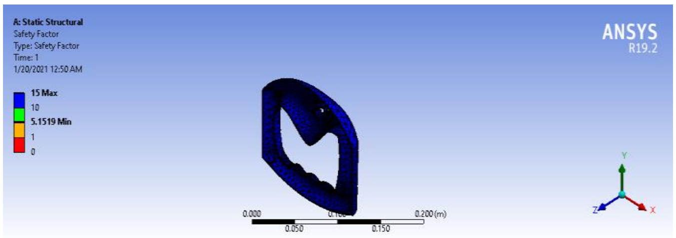

Fig -14: Holder Safety Factor Data

Part of Design	Max. Equivalent stress (Under 600N force) (GPa)	Minimum Factor of Safety (FOS)	Max. Shear Stress (GPa)	Max. Total Deformation (µm)
Button	0.145	4.0307	0.078	15.45
Drum (Spring Cavity)	0.115	5.0699	---	---
Holder Body	0.0471	5.1519	---	7.45

Table- 1: Stress Analysis Data (Ansys)

6. RESULT

This height-adjustable grab holder helps passengers to adjust the height according to his/her will.

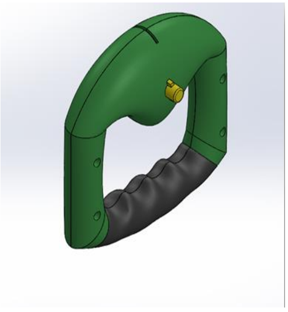

Fig -15 & 16: Grab Holder Design Model & Prototype

7. EXPECTED OUTCOMES

[1] Improved stability
[2] Good endurance
[3] Cost-effectiveness
[4] Ability to operate under all weather conditions
[5] Adjustable holder
[6] Sufficient grip at the hand holding part
[7] Holder fixed at the top
[8] Optimum user experience

8. FUTURE SCOPE

The current design we came up with is mainly focused on being used as an alternative to the existing modes of holders in buses. The use of such holders could be widened to other modes of transports also such as local trains, metros in the future.

9. CONCLUSIONS

The prototype we fabricated when tested was able to satisfy most of our objectives.

[1] It was capable of being adjusted to different lengths according to the user's will.
[2] On manufacturing, the product will be largely similar to the conventional holders.
[3] The button that allows the users to adjust the length of the holder is placed in such a position, thus preventing any accidental adjustment of its length.

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