Design study of Seat Belt Retractor Frame for vehicles

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Abstract – *A safety belt retractor frame will undergo various loads and it consists of various parts in it, which is to be fastened to the vehicle body. Frame which carries the passenger load through a safety belt retractor includes a rear wall and 2 side faces. The rear wall is used to fasten the frame to the weight in body. The fastening section is formed integrally with the rear wall. The rear wall has a hole through which fastening the frame to the body in weight is done. By using rear wall and Body in weight opening, the whole frame is assembled. The frames are fastened through weld, screw, or riveted joint. The fitting is the additional operation which is to be done so it is expensive process. The objective of the paper is to calculate the forces acting on the various teeth of the frame with respect to the clock position by considering the loads and the constraints in the frame, theoretically. To study the tooth strength of the frame the calculations are performed and the respective graphs are plotted.*

Key Words: **Seat belt frame, Safety belt retractor, Weight in body, Teeth of the frame, clock position.**

1. INTRODUCTION

A seat belt is a safety device in vehicle, designed to secure the driver or the passenger in the vehicle against sudden danger that may result during a collision. A seat belt also reduces the causes of death or serious injury in traffic accidents by reducing the secondary impact forces with interior strike hazards, by keeping the passenger positioned correctly for maximum effectiveness of the airbag and preventing the passenger being ejected from the vehicle in a crash or vehicle roll over. While in the motion of the vehicle the passenger and the driver will move in the same speed as the car, when the driver applies a sudden brake the passenger and the driver will be acting same force as the car, at that movement the seat belt applies opposite force to constraint the passenger and driver in the position so that to avoid the contact with the interior of the car or falling out of the car. Seatbelts are called the Primary Restraint Systems for their main role in the driver or passenger safety.

1.1 Seat belt retractor frame

The frame in the figure 1 is the housing for the entire mechanism and it is the final load transmitting component. The frame for a seat belt retractor system including a rear wall and a fastening section, two side faces which provides for at least one of attaching the frame to a section of a component which is fixed to a vehicle and pre-positioning the frame on the section, usually the fastening section being formed integrally with the rear wall and to place the pretentioners and locking mechanism.

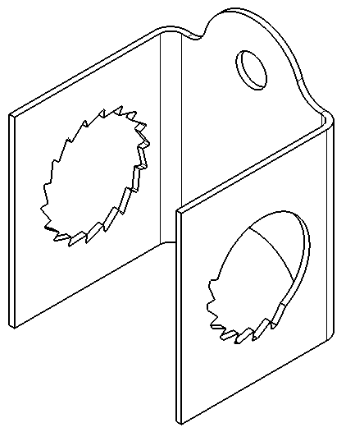

Fig -1: Seat belt retractor frame

1.2 Loads in the frame

- Pull/push
- Cassette spring Locking
- Frame attachment
- Crash loading

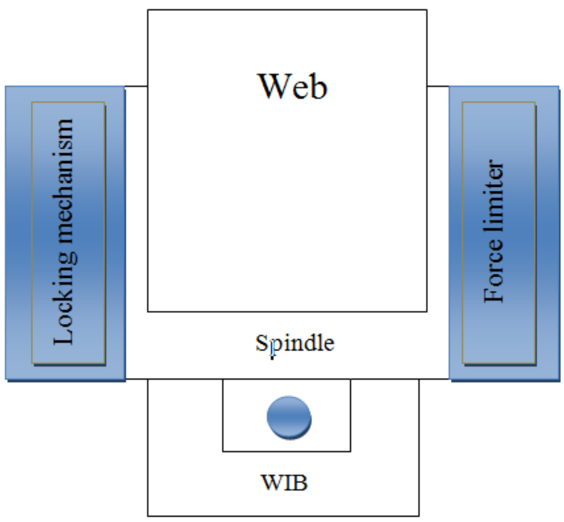

Fig -2: Loads acting in the Retractor frame

The load distribution in the structure of frame is divided into different parts of the frame with respect to figure 2.

When there is an accident the sudden load of the driver or the passenger will act on the belt of the retractor, which will be the load of the occupent, the load is then transferred to the parts of the retreactor to the body in weight. To avoid the sudden movement there is a mechanism in one side of the frame which will exert a force, and in other side there is a force limiter which will also exert force, which is to pressurize the belt and the force will also act in the frame fixation.

Pull/push

Webbing
↓
Spindle
↓
Spring one end
↓
Spring another end
↓
Spring cover
↓
Frame

Crash locking

Webbing
↓
Spindle
↓
Lock dog
↓
Frame
↓
BIW

2. Geometric Properties

In this paper the force transmitted from belt to the frame and then to the body of vehicle is analysed by considering different teeth positions. The different teeth contact result in different clock positions and deformation, also in this paper we find difference in force transmission and the minimum and maximum force transmission path. If the force transmission is more then the deformation in that position will be more. If the applied load is distributed uniformly throughout the area of the frame then the reaction force at the fixed position of the frame will decrease, which will increase the strength of the frame.

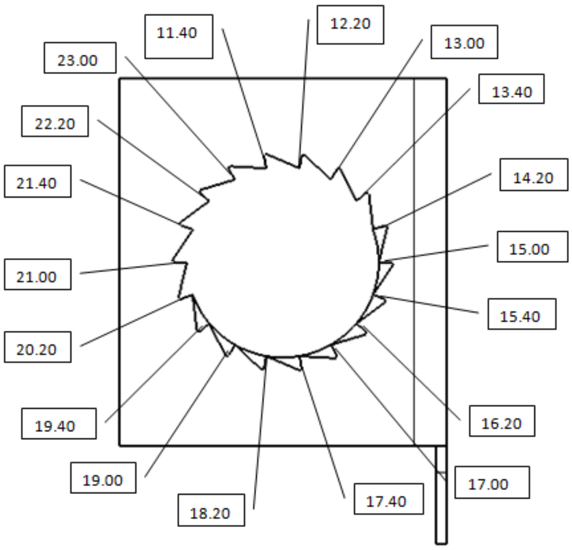

Fig -3: Retractor frame with clock position

2.1 Calculation of force transmitted through different teeth

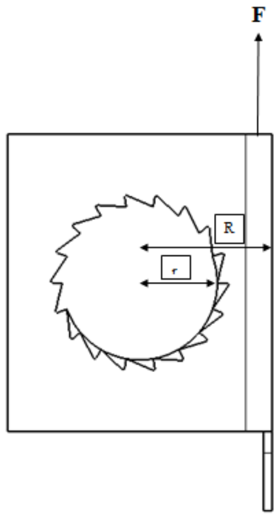

Fig -4: Retractor frame side view

Where, R → Radius from frame to centre of spindle
F → Maximum force Applied
r → Radius of spindle
F_s → Force at spindle
F_t → Force transmitted on both sides of frame

Maximum force Applied, F = 12kN
Torque, T = 389400Nmm
Force at spindle, F_s = 19004.39N
Force transmitted on both sides of frame F_t, = 9500N

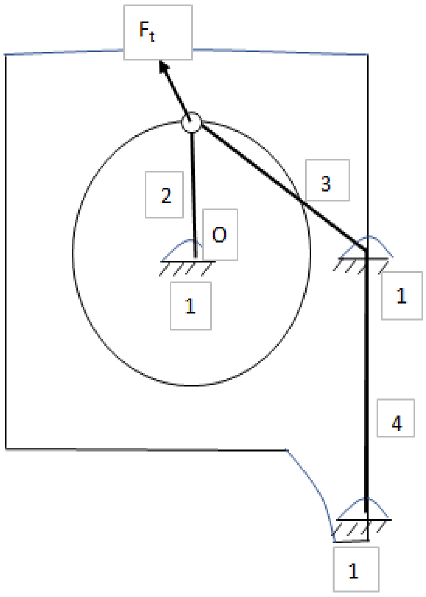

Fig -5: Load link of retractor frame

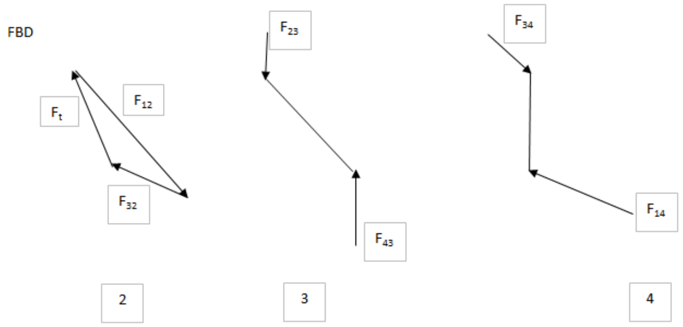

Fig -6: Free body diagram of links

At 11.40,
From CAD model we can find the length of links F_{12}, F_{32} and F_t by polygonal law,
Length of link F_{12} = 19.25mm
Length of link F_{32} = 31.40mm
Length of link F_t = 24.81mm

Taking moment about, O
ΣM_{01}= (Length of F_t*F_t)+(Length of F_{32}*F_{32})=0
F_{32} = -7506.23N
From the free body diagram,
$F_{32}=-F_{12}=-F_{34}=-F_{23}$
$F_{34}=F_{41}=-F_{14}$
Therefore F_{41} = 7506.23N

Similarly by considering different teeth positions and its link lengths from CAD file we can get different values of F_{41} which is the force transmitted to the WIB.

Table -1: Teeth position and various force transmitted

Clock position	Force F_{41}(N)
12:20	8735.19
13:00	9447.16
13:40	9168.90
14:20	6642.04
15:00	5000.00
15:40	6755.03
16:20	9157.70
17:00	9447.15
17:40	8741.05
18:20	7514.12
19:00	5904.25
19:40	4065.27
20:20	2101.21
21:00	2000.00
21:40	2101.27
22:20	4064.87
23:00	5903.91
11:40	7506.23

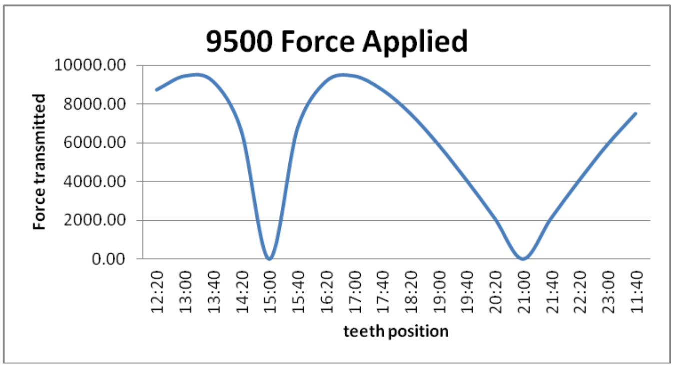

Chart -1: Force transmitted versus teeth position graph

The figure 3 shows the different teeth positions with respect to clock positions.

The figure 4 is the side view of retractor frame and it specifies the distance and the force direction.

The figure 5 shows the different links in the frame. The link 1 and link 4 are fixed and the links 2 and 3 are varied for different teeth position and its length are different in each case.

The figure 6 shows the free body diagram of the forces acting on the frame at 11:40 position.

The table 1 shows the force transmitted from the applied direction to the frame fixed position and its clock position.

The chart 1 shows Force transmitted versus teeth position with respect to clock position.

3. Results and Discussion:

The different teeth position will transmit different forces depending on the link length. If the transmitted force is more, the stress acting on that position will be more, the frame will fail at that position at lower value of stress. The position at which the failure of frame takes place with higher value of withstanding stress will be having higher strength.

4. Conclusions

- In this paper the basics of seat belt retractor and its functional parts are discussed.
- Performance analysis of seat belt retractor frame is performed in this paper by considering constant load in different teeth with respect to clock position.

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