Study and Analysis of Seat Belt Retractor Frame for Vehicles

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Abstract – *A belt retractor is designed to hold the occupant of the car or the other vehicle in a place, if the collusion occurs or if it stops suddenly. The retractor frame connected to th e retractor and the belt will undergo various loads and it consists of various parts in it, which is to be fastened to the vehicle body. Due to the passenger load the frame will be deformed which is connected through various parts of the retractor. The deformation is mainly in certain positions of the frame where it is fixed to the weight in body through the hole using fasteners like screw, weld or riveted joints and the teeth position where the mechanism of the retractor acts on the frame. The objective of the paper is to apply the force and study the stresses acting on the various teeth of the frame with respect to the clock position by considering the loads and the constraints in the frame, using FEA model using Hypermesh software. To study the optimum value of stresses, tooth strength of the frame, analysis is performed and the respective grafhs are ploted.*

Key Words: **Safety belt, Retractor frame, Weight in body, Fastener, Clock position.**

1. INTRODUCTION

A seat belt retractor is a housing unit which contains differential structural integrity. The seat belt retractor has a rigid frame structure and contains the retraction and locking element in it. A spindle is connected to the frame and is permitted to rotate in a controlled fashion as a result of crash force acting on the frame whereby the frame remains undistorted.

The various parts of the seat belt retractor are webbing sensing lever, W S spring, Steering disk, return spring, lock dog, spindle, frame and web belt. These parts makes the retractor working into four sections, which constitutes the system side that provides the locking mechanism along with webbing sensitivity, vehicle sensitivity and automatic locking mechanism, webbing and load limiter integrated spindle, extraction and retraction provided by the spring.

1.1 Structural frame

Belt retractor for a vehicle seat belt system consists of frame as shown in figure 1 which is to be designed for its effective functioning. The U-shaped Sheet metal part usually resembles the frame for a belt retractor. The two sides of the frame will consists of the spool on which the seat belt is wound and unwound with the help of the spindle. The frame is fixed to the body of the vehicle with the help of its rear wall which is connected to the two side surfaces and forms a integrated structure.

A fixing tab or nut is provided at the rear wall of the frame by welding or bending for the purpose of constraining or fixing of the frame to the vehicle body. The rear wall is perfectly perpendicular to the two side surface of the frame to place the spindle in between for winding or unwinding of the belt. To temporarily fix the frame to the body of the vehicle or properly place the frame in its position the bent T or fixing tab is provided at the rear wall of the frame so that it can be fixed with the slot in the body of vehicle. This is the additional operation in the frame for its fixation which will also lead to increase operation time.

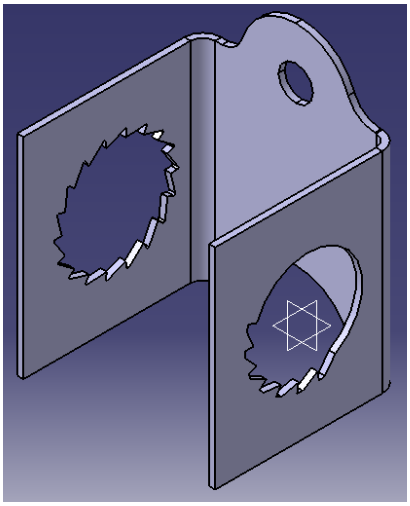

Fig -1: Catia model of seat belt retractor frame

1.2 Material properties and formation of retractor frame

Mild steel, also known as plain-carbon steel and low-carbon steel, is the most well known form of steel because of its price which is moderately low. Its material properties are benefit for many applications. Mild steel contains around 0.05–0.30% carbon, making it malleable and ductile. Mild steel has a relatively low tensile strength, but it is cheaper and easy to form, its surface hardness can be increased via carburizing. In sheet metal forming low carbon steel is widely used. The frame of the retractor is also made using low carbon steel.

The frame or the housing of a seat belt retractor is made from sheet metal. This sheet metal undergoes various sheet metal operations for the production of the frame like notching for the slots to mount to the body of the vehicle, piercing for the bolt hole, piloting to arrest the movement while operations, blanking to separate various frames from the sheet metal and U bending to obtain the desired design specifications. Coatings are given to the frame to prevent corrosion. Embossing or forming is done to derive additional features of the frame.

2. Geometric and Finite element analysis

The structure of the frame is U shape in which the rear surface will be constrained by using fasteners and two side surfaces are applied by some force. The identification of the different teeth is done by using its respective clock position. The clock position is numbered from 11:40 to 23:00 with the step of 40 minutes.

The passenger weight is the applied force on the belt and the retractor. The constant force or the maximum force is considered to be acting on the teeth and the deformation of the frame is obtained according to that. The stress values are obtained depending on the force applied and the geometry of the frame. The geometry of the frame or the load path will differ for each tooth depending on the applied force direction and position. Various teeth positions of retractor frame are shown in figure 2 below.

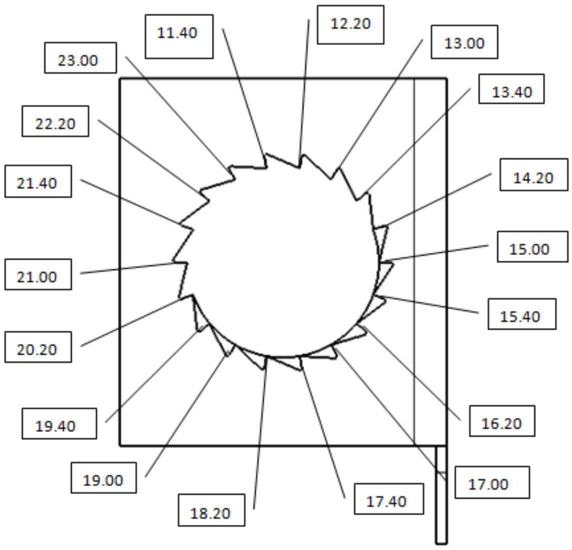

Fig -2: Retractor frame with clock position

The meshed model in figure 3 is done using hypermesh software. The CAD model is imported into the preprocessor and meshed. After the geometric clean up the loads and constraints are imposed on the model and using opti struct solver the results are obtained.

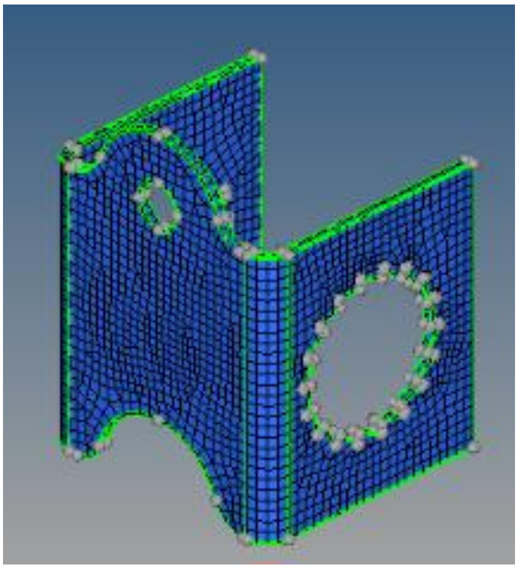

Fig -3: Meshed model of seat belt retractor frame

2.1 CAE Approach

The frame is made to fix in one section and the constraint is applied in that portion of the frame and the actual load from the seat belt is applied and transfered to the different teeth's of the frame at this position the constant force is applied. This is carried out in hypermesh software and the stresses are obtained in the structure of the frame.

The J_2 plasticity or J_2 flow theory of Von Mises yield criterion states that when the second deviatoric stress invariant J_2 reaches a critical value k the yielding of the materials begins. For this reason, it is called. The Von Mises criterion is based on the determination of the distortion energy in a given material. This criterion also states that as the maximum value of the distortion energy per unit volume in that material remains smaller than the distortion energy per unit volume required to cause yield in a tensile test specified of the same material the structural material will be safe. The von mises equation is given by,

$$(\sigma_1 - \sigma_2)^2 + (\sigma_2 - \sigma_3)^2 + (\sigma_1 - \sigma_3)^2 = 6k^2 = 2\sigma_y^2$$

2.2 Corelation of Von Mises yield criterion

Hencky offered a concept of Von Mises criterion relating that when the elastic energy of distortion reaches a critical value, the yielding begins and is called as maximum distortion strain energy criterion.

The relation between J_2 and the elastic strain energy of distortion W_D is given by:

$$W_D = J_2/2G$$

Where,

$$G = E/2(1+\nu)$$

In case of octahedral shear stress, Arpad L Nadai concept states that when the octahedral shear stress reaches a critical value yielding begins and also called as maximum octahedral shear stress criterion.

The relation between J_2 and the octahedral shear stress T_{oct}:

$$T_{oct} = \sqrt{2}/3\ \sigma_y$$

At 12:20

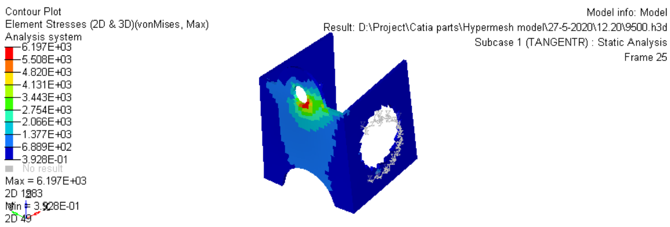

Fig -4: von mises stress at 12:20 clock position

The figure 4 shows the of Von Mises stress concentration in the frame at 12:20 clock position. Then the analysis is carried out in remaining 17 teeth position in the same way and the results are tabulated in table 1 below. From the analysis compared to other teeth position it can be found that the teeth at 21:40 clock position the stress concentration will be more.

Table -1: Teeth position and von mises stress

Clock position	CAE (stress) N/mm²
12:20	6197
13:00	3379
13:40	1584
14:20	4006
15:00	6157
15:40	7017
16:20	7612
17:00	7149
17:40	6554
18:20	5584
19:00	5038
19:40	8101
20:20	10630
21:00	12290
21:40	13290
22:20	13070
23:00	11660
11:40	9210

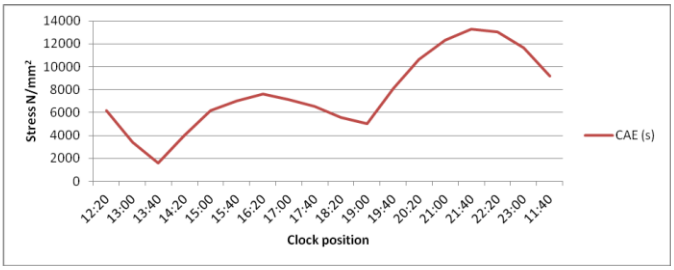

Chart -1: stress versus clock position

The table 1 shows the teeth position and the vonmises stress obtained from the Hypermesh software.

The chart 1 shows the stresses in different teeth versus clock position.

The linear static analysis is performed for the frame in the elastic limit. Since the stiffness matrix is constant we will get the faster and better result. In software we will get the colour format of result in which red for failure and blue for safe design and analysed for maximum and minimum stresses in the frame to evaluate its safe and failure regions.

3. Results and Discussion:

The stresses acting in the different teeth position will depends on the structure of the frame. At 13:40 clock position the frame will fail at lower value of stress and at 21:40 clock position due to its structure change it can withstand higher values of stress. If the more force is transmitted in the structure of the frame, the stress acting on that position will be more, the frame will fail at that position at lower value of stress. The teeth which have higher strength will fail at higher value of withstanding stress.

4. Conclusions

- In this paper the concepts of seat belt and its structural parts are discussed.
- Material and geometric properties of the seat belt retractor frame is discussed in this paper.
- The FEA analysis of the different load path is performed in this paper.

5. Scope for future work:

- The stresses can be further reduced by using stiffeners and increasing the strength of the frame.
- Also by changing the tooth profile of the frame the forces acting on it can be improved.

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