International Journal of Innovative Research in Computer Science & Technology (IJIRCST)
ISSN: 2347-5552, Volume-10, Issue-6, November 2022
https://doi.org/10.55524/ijircst.2022.10.6.23
Article ID IRP1332, Pages 149-152
www.ijircst.org

3D Modeling and Static Analysis of Telescopic Shock Absorber Unit

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ABSTRACT- In this paper, we present the 3D modelling and structural analysis of a telescopic shock absorber unit that have been considered. A telescopic shock absorber unit from railway wheels was used in this study. The 3D model of a telescopic shock absorber unit consists of a cylinder, Belleville disc, eye ball, flange models that were created with the help of CATIA V5 software, and Finite Element Analysis (FEA) is also carried out to find the Equivalent Von-Misses stresses and deformations to reduce the bouncing, stability, and improve the performance of a shock absorber unit.

KEYWORDS- Telescopic Shock Absorber, 3D Modeling, Belleville disc, Cylinder, Flange, Eye ball, FEA. Railway

I. INTRODUCTION

A shock absorber or dashpot is a mechanical device designed to smooth absorb and reduce the bouncing of the shock loads. Also, this device converting the kinematic energy of the shock in to heat dissipated energy. S.Martande et.al [1] studied about the boundary conditions, applied loads, and deformation of shock absorber. A.Patel et.al [2] studied and compared about the conventional steel material and composite material of shock absorber springs when the load is applied on the axial direction and its changes the material properties of composite lay-up.Tekade R.A et.al [3] studied about the deformation characteristics of truncated conical shape of shock absorber subjected to under the axial compressive loads. Sreenivasan.M et.al [4] enhanced load and deformation characteristics values of cone type shock absorber spring based on the proposed energy or computational method. Dolas.D.R et.al [5] reveals the information about the relative values of analytical and FE-deformation of the spring stiffness, flange and eye bolt when load is subjected to axial direction.Gunaki et.al [6] studied about the effect of friction, vibration and displacement characteristics of cone type springs by use of FE static analysis.K.Aravind et.al [7] studied effect of elastic deformation, inner and outer boundary constraints of eight noded isoparametric cone spring element is analysed by use FEM when axial UDL applied at free edges. Mulla et.al [8] studied varying thickness of conical shell spring to find out the equilibrium displacements through the principle method.Vukelic. G et.al [9] investigate brake load on the various structures of disc spring with effect of various lubrication systems by use of ABAQUS and Numerical model analysis Bhasha A.C.M. et.al [10] investigated shock absorber strength, stiffness and FE analysis of with and without ladings to determine the optimal parameters. P.P.Mohan et.al [11] investigated cone-disk springs to determine the load Vs deflection curves at various proportions of the spring input parameters. Johnson et.al [12] investigated to compare steel and beryllium copper of shock absorber to determine the strength and stiffness. Based on the exhaustive literature survey no author has been to design and FE analysis of Telescopic shock absorber unit of railway wheels. Finally in this paper to calculate the stresses and deformations of the 3D modeled shock absorber unit.

II. SHOCK ABSORBER UNIT

Shock absorber unit having the following components i.e. eye ball, flange, cylinder, bolts (fasteners. The telescopic shock absorber unit serves as outer casing and is connected to tow bars and the damaged battle tank via sprockets and disc springs are mounted on the eye ball as shown in Figure 1.

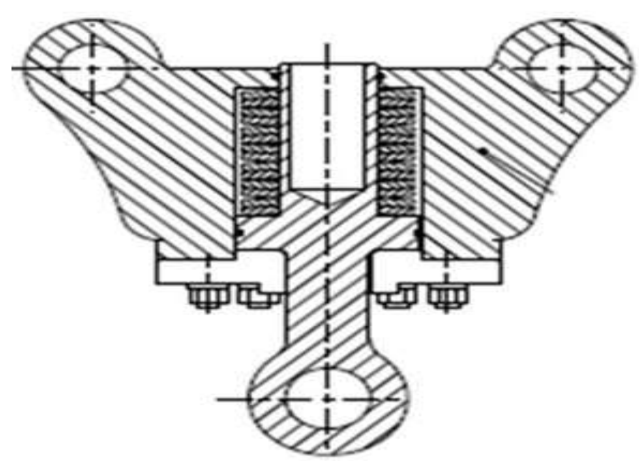

Figure 1: Shock absorber unit

III. 3D MODELING OF SHOCK ABSORBER UNIT

A. Modeling

In this paper 3D modeling software used as CATIA V6, was helpful to drafting for the each part of the shock absorber unit i.e. (a) cylinder (b) flange (c) eye ball (d) mounted plate according to the dimensions [13] as shown in Figure 2.

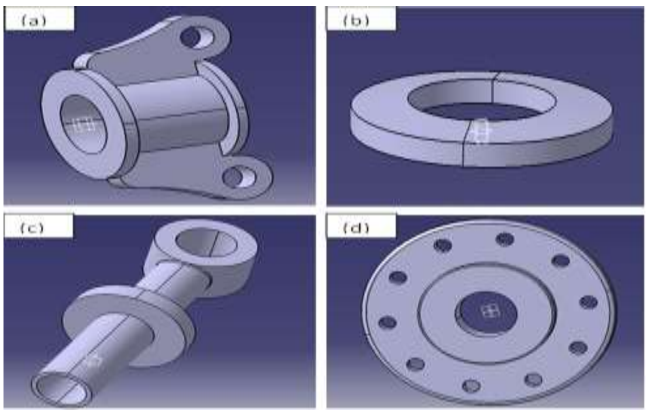

Figure 2: Shock absorber components (a) Cylinder (b) Flange (c) Eye ball (d) Mounted plate

B. Assembly of Shock Absorber Unit Components

In this 3D modeling CATIA V6 software is used to assembly the (a) Cylinder (b) flange (c) eye ball (d) mounted plate and Belleville spring to form a shock absorber unit. In this shock absorber assembly is exported to Hyper mesh for meshing, eye ball is the part which will be inside the outer casing where outer casing is connected with flange, and flange and outer casing are connected with bolts and eye ball is free to movie inside the outer casing and Belleville spring is mounted on the eye shaft there are series and parallel combination of Belleville spring, initially the Belleville spring is mounted on the eye shaft during assembly and this shaft with Belleville spring is assembled with outer casing and later on flange is assembled to this assembled part the entire assembly is carried out using CATIA Software. The above assembly gives clear picture about the springs mounted on eye ball shaft in this the flange is attached to eye ball flange, this assembly will be inside the shock absorber cylinder.

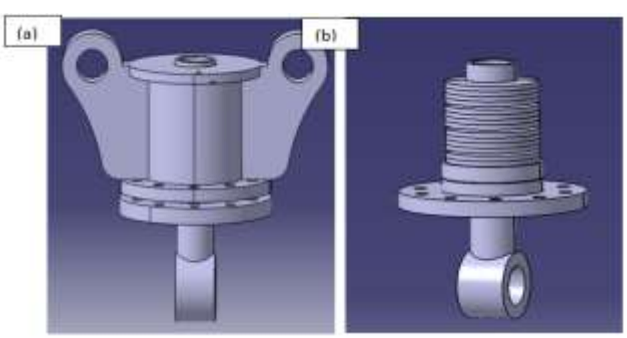

Figure 3: Assembly unit of shock absorber

C. Meshing of Shock Absorber Cylinder

After assembly of shock absorber unit in CATIA V6 software, after that shock absorber unit imported to hyper mesh software to mesh this part to select quadrilateral element for outer casing / shock absorber cylinder is the outer surface as shown in Figure 3.

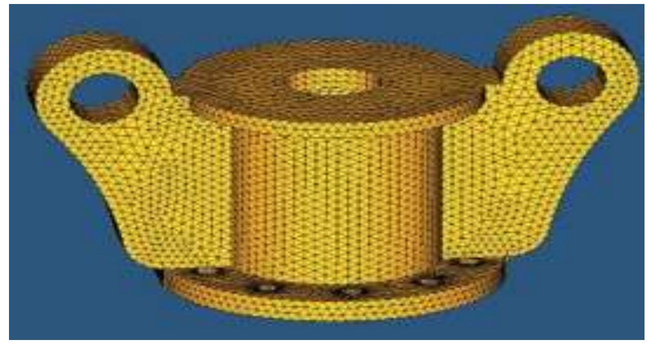

Figure 4: Shock absorber cylinder (meshed part)

IV. RESULT AND DISCUSSIONS

In this paper to carry out the shock absorber unit is subjected to the two load conditions i.e. Tensile and compressive loads. The input mechanical properties are defined in table 1. Initially when the shock absorber unit is connected to damaged vehicle with the help of tow bars, initially when the recovery vehicle starts up in order to pull the damaged vehicle tensile force will be acting on the shock absorber unit when the towing vehicle must be bought down from rest to moving, again once the recovery vehicle applies the sudden breaks the damaged vehicle creates the inertia load, which in turn sudden compressive force will be acting on the shock absorber unit this is the another condition so in this project the analysis is done for the two cases one is compressive and another one is tensile.

Table 1: Mechanical properties of structural steel

Thickness (mm)	Yield strength (MPa)	Tensile strength (MPa)	Elongation (%)
4-53	700	780-930	14
53-100	650	780-930	14
100-160	650	710-900	14

A. Tensile Loading Analysis of Shock Absorber Unit

From the table 2 tensile results are concluded that the design of shock absorber unit is safe so manufacturing of this assembly can be carried out, from theoretical to analysis results the error was 7%, error was below 15 % hence this is recommended, it is recommended because Based on the past project which has been carried out in the industry based on their past experience they concluded that analysis carried out for the tensile case is correct based on the experience the factor safety obtained is also safe as shown in Figure 4

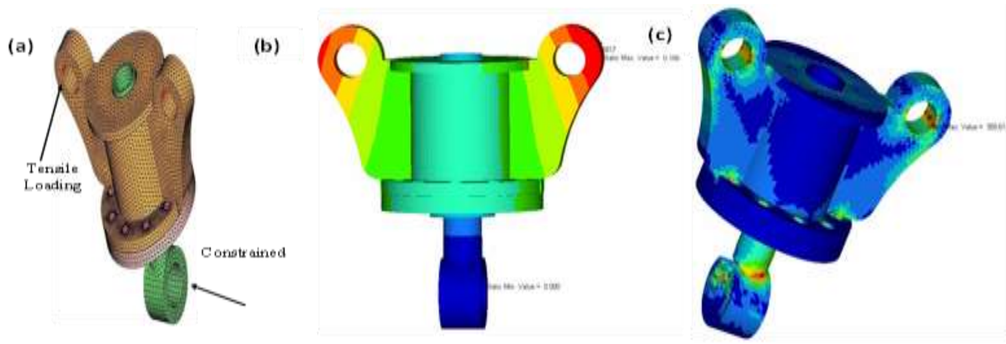

Figure 5: Tensile loading of shock absorber (a) B. Cs (b) Deformation (c) Von-Misses Stresses

Table 2: Tensile Values of shock absorber unit

Displacement	0.157 mm
stress	359 N/mm^2
factor of safety	2
theoretical results	387 N/mm^2
Error	7%

B. Compressive Loading Analysis of Shock Absorber Unit

From the table 3, compressive results concluded that the design is safe so manufacturing of this shock absorber unit can be carried out the stress what we got from analysis was well below the yield stress for the material used hence the design is safe, error found was 11% Hence this is recommended. it is recommended because Based on the past projects which has been carried out in the industry based on their past experience they concluded that analysis carried out for the tensile case is correct based on the experience the factor safety obtained is also safe as shown in Figure 5.

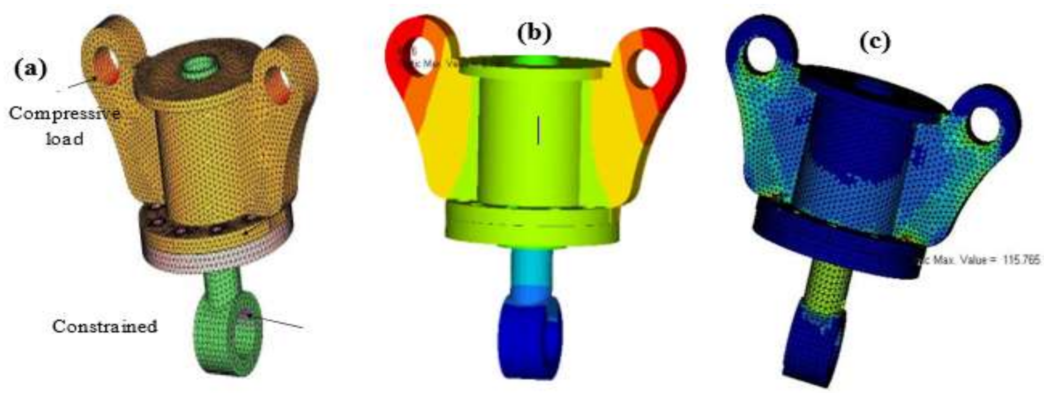

Figure 6: Compressive loading of shock absorber (a) B. Cs (b) Deformation (c) Von-Misses Stresses

Table 3: Compressive Values of shock absorber Unit

Displacement	0.16 mm
Stress	115.6 N/mm^2
Factor of safety	6
Theoretical results	103.2 N/mm^2
Error	11%

C. Comparisons of Theoretical and Experimental Values of Shock Absorber

From the Table 4, it is clear that for various dimension of Belleville spring and load values the hand calculations results are matching with experimental DIN standard values which was given by the BEML hence Belleville spring was well suited for this project requirement.

Table 4: Comparison b/w theoretical and experimental

Theoretical			Experimental		
Deflection inmm	Stress at Point 2 in N/mm^2	Stress at Point 3 in N/mm^2	Deflec-tion in mm	Stressat Point 2 in N/mm^2	Stress at Point 3 in N/mm^2
1.325	115	544	1.35	118	547
1.19	275	593.23	1.20	276	593

V. CONCLUSION

In this project, we find the following important factors:

- Designing shock absorber unit using suitable springs, the problem was selecting a suitable spring that should satisfy the given conditions, such as having the maximum compressive load with the minimum deflection and being well fitted to the given space requirements. For this suitable study was done on the Helical spring and Belleville spring.
- In this project, parts of the shock absorber unit are meshed, loads are applied, boundary conditions are given, and parts are analyzed separately. Results are tabulated, and further, the assembly of the shock absorber unit is analyzed in two conditions, such as tensile and compression, and results are tabulated. Based on the results and discussion, it is concluded that the stresses obtained were less than the material's yield stress, indicating that the design is safe.
- Further, the Belleville spring calculation was validated with experimental DIN standard values that have been given by the BEML; hence, it is concluded that this conceptual design of a shock absorber unit is taken for manufacturing and this can be attached to a recovery vehicle for towing.

CONFLICTS OF INTEREST

The authors declare that they have no conflicts of interest.

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