Structural Analysis and Optimization of Anti-roll bar

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Abstract — **Anti-roll bar is the part of an automobile suspension system that connects the left and right wheel members through short lever arms and is clamped to the vehicle chassis with rubber bushes. It forces each side of the vehicle to lower, or rise, to similar heights, to reduce the sideways tilting (roll) of the vehicle on curves, sharp corners, or large bumps. It also resists roll or swaying of the vehicle which occurs during cornering or due to road irregularities. In this study FEA is carried out to perform structural analysis in ANSYS Parametric Design Language (APDL). Parametric modeling and stress analysis of the component will be performed using the Input listing method. This analysis will be validated by performing tests on scaled model. Then this validated parametric method will be used for further analysis of the actual component. Then optimization will be carried out to establish a method for weight reduction.**

Keywords— Structural analysis, APDL, Optimization

1 Introduction

Anti-roll bar is also known as anti-sway bar, sway bar or stabilizer bar. It is the part of many automobile suspension systems, which helps to reduce the body roll of a vehicle during fast cornering or over road irregularities. It is a rod or tube which is usually made of steel, that connects the right and left suspension member together to resist the roll or swaying. The bar's torsional stiffness (resistance to twist) determines its ability to reduce body roll, and is named as “Roll Stiffness”. When one road wheel is deflected more than the other, e.g. when it comes over a bump on the road or during hard cornering, there is a tendency for the vehicle to roll. To obviate this tendency, a stabilizer is used in the form of a torsion bar.

Parameter	Initial Design	Unit
Length **L**	1100	mm
Width	230	mm
Outer diameter $\mathbf{D_o}$	21.8	mm
Thickness	2.9	mm
Bush Length	40	mm
Position of Bush	±390	mm
Corner Radius	50	mm

Table 3.1 Anti-roll bar Model data

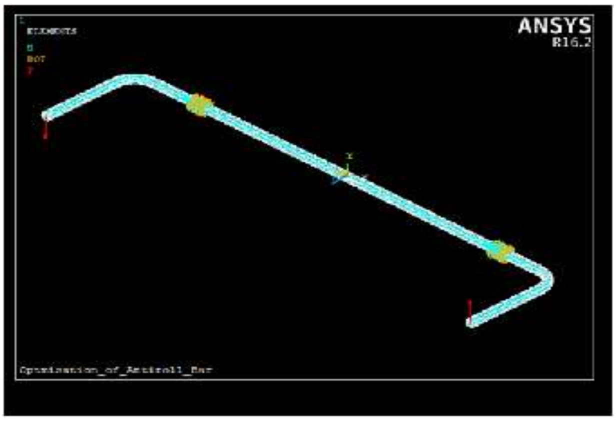
PARAMETRIC MODELING

In parametric modeling a model built and analyzed in terms of *parameters* (variables) instead of numbers. By simply changing the values of certain parameters in the model, one can build and analyze a new model. The shape of the component will remain constant but the dimensions can be changed as per the requirement. Using *ASK command we can ask for values of parameters from user using prompts the user. Using *SET command the values are directly assigned to user-named parameters. Once we create the model in parametric modeling then there is no need to create it again and again for the different dimensions. We just need to change the values of parameters and the model will be created directly so the time consumed for modeling will be less.

ANALYSIS OF ANTI-ROLL BAR

The analysis of anti-roll bar is carried out in the ANSYS Parametric Design Language and parametric model is prepared using the input listing method. Initially the key points are created and accordingly the line model is prepared then using the beam 188 element model is prepared. Then model is meshed and boundary conditions are applied as shown and analysis is completed

Anti-roll bar model information



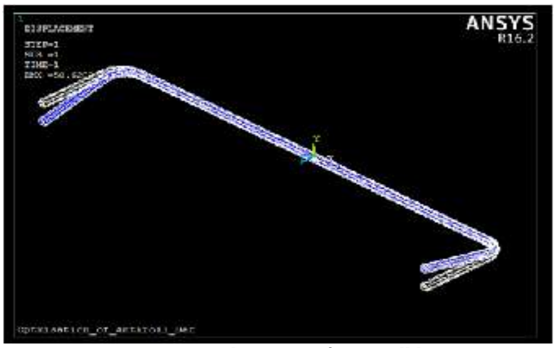


Figure 1. Displacement of Anti-roll bar

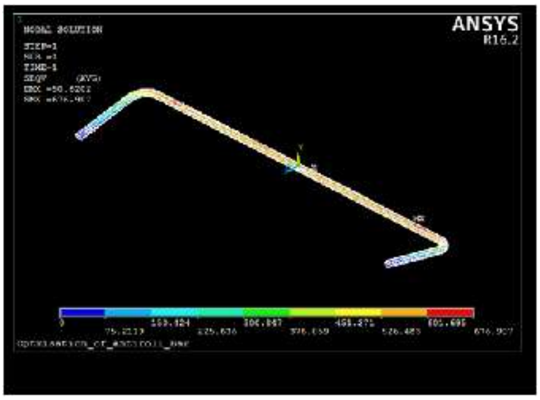


Figure 2. Equivalent stresses in Anti-roll bar

EXPERIMENTAL WORK

The testing of the scaled model of the antiroll bar subjected to known forces is carried out. The deflections are measured and compared with the results obtained by ANSYS. The experimental setup is as shown in figure


Figure3. Experimental setup of anti-roll bar for finding deflection

Table 4.1 Deflection observed at different loads in upward direction

Sr. No	Upward Force					
	Load (kg)	Force (N)	Height gauge readings(mm)		Experimental Result	ANSYS Result
			Without Load	With Load	Deflection (mm)	Deflection (mm)
1	10	98.1	244.5	248.18	3.68	3.53
2	12.15	119.1915	244.5	249.48	4.98	4.29
3	15	147.15	244.5	250.03	5.53	5.3

Sr. No	Downward Force					
	Load (kg)	Force (N)	Height gauge readings(mm)		Experimental Result	ANSYS Result
			Without Load	With Load	Deflection (mm)	Deflection (mm)
1	10	98.1	249.23	245.51	3.72	3.53
2	12.15	119.1915	249.23	244.25	4.98	4.29
3	15	147.15	249.23	243.68	5.55	5.3

Table 4.2 Deflection observed at different loads in downward direction

OPTIMIZATION OF ANTI-ROLL BAR

For optimizing the anti-roll bar following parameters are considered i.e. Outer diameter, corner radius, thickness and position of a bush. Optimization is carried out using the APDL and the stiffness kept constant, the results of optimization are

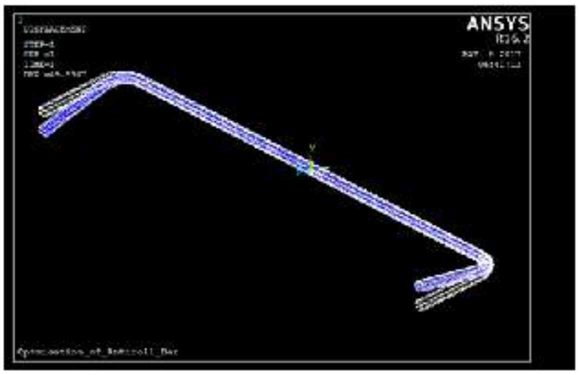


Figure 5.2 Displacement of optimized model of Anti-roll bar

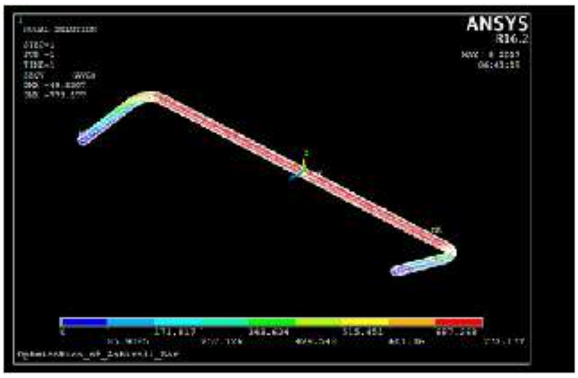


Figure 5.3 Equivalent stresses in optimized model of Anti-roll bar

MODAL ANALYSIS OF ANTI-ROLL BAR

Modal analysis of automobile components has great importance in ride comfort studies. The vibrations and noise, to which the passenger is exposed, should be kept within certain limits. This fact brings the requirement of determining the natural frequencies and mode shapes of the vehicle components, and this applies clearly for the anti-roll bar.

The modal analysis results for original model of anti-roll bar are as shown below

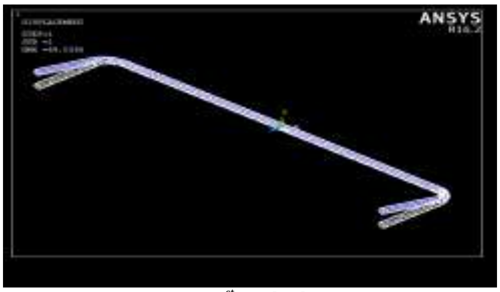


Figure 1st mode shape

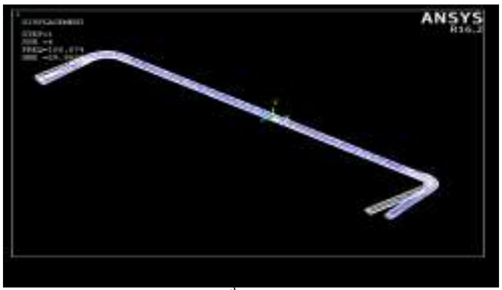


Figure. 4th mode shape

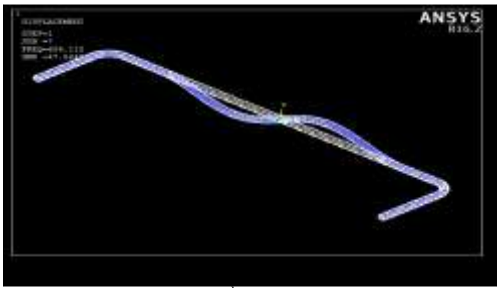


Figure. 7th mode shape

The modal analysis results for optimized model of anti-roll bar are as shown below

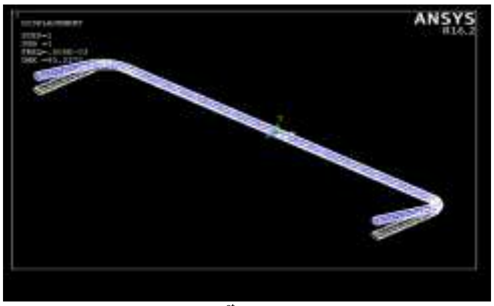


Figure. 1st mode shape

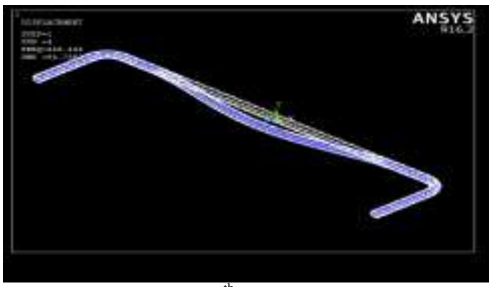


Figure. 4th mode shape

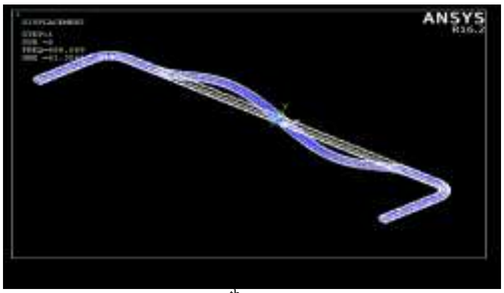


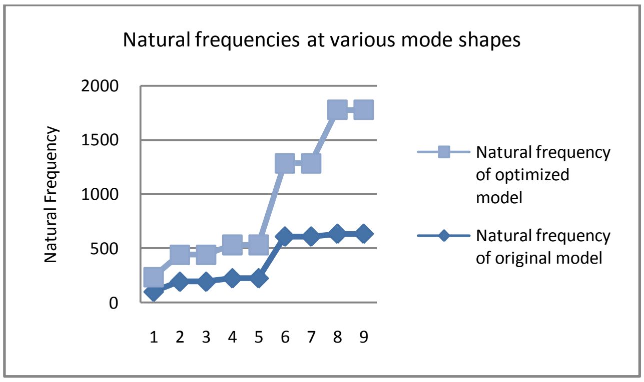
Figure. 8th mode shape

RESULT AND CONCLUSION

The result of modal analysis is shown in following table

Table 5.2 Natural frequencies at various modes

Mode Shape	Natural Frequencies of Original model (Existing) (Hz)	Natural Frequencies of Optimized model (Hz)
1	98.957	135.38
2	191.14	250.05
3	191.14	250.05
4	222.72	307.32
5	222.72	307.32
6	606.11	675.63
7	606.11	675.63
8	631.54	1141.6
9	631.54	1141.6



Some trial runs of optimization result are as shown in table below

Trial Run no.	Feasibility	Outer Diameter (mm)	Thickness (mm)	Corner radius (mm)	Von mises stresses (MPa)	Deformation (mm)	Weight (Kg)
1	Feasible	21.8	2.9	50	633.02	49.974	2.049
2	Feasible	21.824	2.7868	50.374	642.24	50.923	1.9487
3	Feasible	21.923	2.7172	50.675	640.92	50.871	1.9501
4	Feasible	22.324	2.4606	51.785	654.49	50.972	1.8253
5	Feasible	22.891	2.178	53.125	671.65	50.963	1.6834
6	Feasible	24.06	1.7476	54.911	707.06	51.003	1.4536
7	Feasible	26.139	1.2685	50.955	766.89	50.92	1.1761
8	Feasible Optimized	26.969	1.1626	54.911	773.16	49.804	1.1185
9	Infeasible	26.962	1.1357	54.911	789.57	50.875	1.0934
10	Infeasible	26.962	1.1343	50.928	790.38	50.928	1.0922

CONCLUSION

By experimental method the deformation is find out using by applying the different loads. The experimental results of deformation and the results calculated by ANSYS are also very close. The percentage variation observed is 4.24% to 4.71%.

Table 6.1 Result comparison for existing and optimized anti-roll bar

Parameters	Existing	Optimized
Weight	2.049 kg	1.1185 kg
% Change in Weight	45.41 % of weight is reduced in optimized model	
Von mises Stress	633.02 MPa	773.16 MPa
% Change in Stress	The von mises stress in the optimized model is increased by 22.13% but its within allowable limit	
Deformation	49.974 mm	49.804 mm
% Change in Deformation	Negligible change in deformation is observed	

Through this analysis the results are observed that which are summarized in the following way

- By the analysis of parametric modeling of existing/ reference model of the Anti-roll bar, It is observed that the von mises stresses are 676.907MPa and deformation is 50.62 mm.
- Further the optimization is carried out and the optimized model parameters are obtained.
- By the analysis of optimized model the von mises stresses obtained are 773.16 MPa which are within the allowable limit and the deformation is 49.804 mm which is acceptable.
- The outer diameter of the optimized model is 26.969 mm. As the outer diameter of the Anti-roll bar increases the stresses are increasing but are within the allowable limit and the weight of the bar decreases.
- The thickness of the optimized model is 1.1626 mm. As the thickness of the anti-roll bar decreases the stresses increase but within the allowable limit and the weight of the bar reduces.
- For the optimized model the distance of the bush from center is 426.72 mm. As the distance of bush increases from center the stresses reduces.
- The optimized model corner radius is 54.911 mm. The mass is dependent on the radius and when the radius increase the mass decreases.
- In the optimized model as the mass of the model is reduced and stiffness is kept constant, the natural frequencies are increasing.
- The weight of the parametric model is 2.049 kg and the weight of optimized model is 1.1185 kg.
- Experimentally the deformations are calculated by applying the various known weights and the ANSYS results are compared with it then it is observed that there is variation only upto 4.24% to 4.71%

REFERENCES

[1] J. E. Shigley, C.R. Mischke, "Mechanical Engineering Design", 5th Ed. McGraw-Hill, pp. 282-289, 1989
[2] Kemal Çalişkan "Automated Design Analysis Of Anti-Roll Bars" ‖ SAE PP. 2003-01- 3522.
[3] Somnay, R., Shih, S., "Product Development Support with Integral Simulation Modeling", SAE Technical Paper Series, paper No: 1999-01-2812, 1999.
[4] Mohammad Durali and Ali Reza Kassaiezadeh "Design and Software Base Modeling of Anti- Roll System" SAE PP – 2002-01-2217.
[5] Ian Czaja, Mohammad Hijawi , Automotive Stabilizer Bar System Design and Reliability Society ofAutomotive Engineers(SAE) journal 2004-01-1550
[6] Leal, L., Rosa, E.,Nicolazzi, L.,Uma Introdução à Modelagem Quase-Estática de Veículos Automotores de Rodas Internal Publication, Universidade Federal de Santa Catarina, Florianópolis, Brazil, 2008.
[7] Ian Czaja, Mohammad Hijawi , Automotive Stabilizer Bar System Design and Reliability Society of Automotive Engineers(SAE) journal 2004-01-1550
[8] S. Gosselin - Brisson , M Bouazara and M.J Richard "Design of an active anti-roll bar for vehicles" Shock and Vibration 16 (2009) 155–174 155
[9] Senapathi, S. Shamasundar, G. Venugopala Raoand B. M. Sachin "Endurance testing and FE analysis of four wheeler automobile stabilizer bar" Presented at TopTECH SAE and ARAI, Feb, 2009.
[10] Prof. Laxminarayan Sidram Kanna, Prof. S. V. Tare, Prof. A. M. Kalje "Feasibility of hallow stability bar" IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE) e-ISSN: 2278-1684, p-ISSN: 2320-334X
[12] P. M. Bora, Dr. P. K. Sharma "Vehicle Anti-Roll Bar Analyzed Using FEA Tool Ansys" Volume No.02, Issue No. 07, July 2014
[13] Deepali L. Gore, S. K. Bhor "Design & Optimization Of Antiroll Bar & Development Of Test Rig For Performance Measurement" International Engineering Research Journal (IERJ) Special Issue 2 Page 5918-5922, 2015, ISSN 2395-1621
[14] Mr. Husen J. Nadaf, Prof A. M. Naniwadekar " Analysis of Anti-Roll Bar of Passenger Car for its Nonlinear Behavior with Help of CAE " International Journal of Science Technology & Engineering | Volume 2 | Issue 01 | July 2015
[15] Karan K. Sharma, Arshad Rashid, Saiprasad Mandale "Analysis of Anti-Roll bar to Optimize the Stiffness" e-ISSN No.:2349-9745, Date: 2-4 July, 2015@IJMTER-2015