IOP Conference Series: Materials Science and Engineering

Comparative study between double wish-bone and macpherson suspension system

To cite this article: Shoaib Khan *et al* 2017 *IOP Conf. Ser.: Mater. Sci. Eng.* **263** 062079

IOP Conf. Series: Materials Science and Engineering **263** (2017) 062079 doi:10.1088/1757-899X/263/6/062079

Comparative study between double wish-bone and macpherson suspension system

Shoaib Khan, Yagvendra Joshi, Ashutosh Kumar and Ramesh Babu Vemuluri
School of Mechanical Engineering, VIT University, Vellore-632014, Tamil Nadu, India.

Email id: rameshbabu.v@vit.ac.in

Abstract: The present paper proposes comparative study between Double Wish-Bone and Macpherson Suspension system. The objective is achieved by using ANSYS simulation package. Dynamic and static loads are applied on the suspension systems. Various analysis such as Structural analysis with static as well as dynamic loading, Modal analysis and Transient analysis are carried out in order to study deflection, stress, frequency and strain of both the suspension systems and a thorough comparative study is accomplished.

1. Introduction

The two of the most popular suspensions systems for cars are the Double wishbone suspension system and the MacPherson's strut suspension system. While double wishbone system is mostly used at the rear end of the car, MacPherson is normally used at the front end of the car. Both types of suspensions have their own benefits and limitations, thus comparative study has been made considering the advantages and disadvantages of both systems.

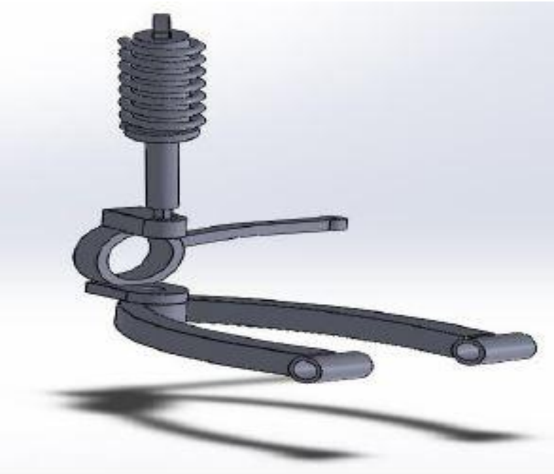

Figure 1. Model of MacPherson

Figure 2. Model of Double Wishbone

MacPherson struts consists of a wishbone or a substantial compression link stabilized by a secondary link which provides a bottom mounting point for the hub or axle of the wheel. This lower arm system provides both lateral and longitudinal location of the wheel. The upper part of the hub is rigidly fixed to the inner part of the strut, the outer part of which extends upwards directly to a mounting in the body shell of the vehicle. The strut is simple in design and thus takes less space. As a result, one can get more passenger space in the car. This also decreases the overall weight of the vehicle. On the other hand, the MacPherson struts have problem with the small camber change with vertical movement of the suspension, which means the tires have less contact with the road during cornering which in turn will decrease handling abilities of vehicle.

Primary benefits of Double Wishbone system is the increase of negative camber as a result of the vertical suspension movement of the upper and lower arms. This results in better stability properties for the car as the tires on the outside maintain more contact with the road surface which also increases handling performance. The double suspension system is much more rigid and stable than other suspension systems, as steering and wheel alignments are constant even when undergoing high amounts of stress but the major problem with double wishbone is its complicated design, failure of any parts leads to failure of the whole system. Both the suspension systems have their own benefits and limitations. To conclude, double wishbones may perform better, but the MacPherson struts would prove to be more affordable in the long run.

2. Literature review

Liu et al. discussed lateral force that exists in Macpherson suspension system which causes damper side wear, proposed the replacement of traditional coil spring with new side load spring with curved centreline for improvement in performance [1]. Finite Elements Analysis combined with Multi-body Dynamics was used to optimize the design and to reduce the lateral force. The final result concluded with the improvement in design and reduction of lateral force. Purushotham discussed Macpherson strut suspension system and proposed systematic and comprehensive development of a two-dimensional mathematical model of a McPherson suspension [2]. Vertical motion of chassis and rotational motion of unsprung mass is also considered. Matlab (Simulink) was used for implementation of model. The Ansys software was used to implement a simplified two dimensional practical model of McPherson suspension. The results obtained from Ansys model were compared with the mathematical model implemented on Simulink. It was observed that the displacement and acceleration of the chassis of the automobile obtained in ANSYS are nearer to the values of mathematical model. Vivekanandan et.al analysed double wish bone suspension system for terrain vehicle with an objective to improve the design and stability [3]. Suspension was designed considering the dynamics of vehicle using Lotus and Ansys. As a result better handling and comfort was achieved.

IOP Conf. Series: Materials Science and Engineering **263** (2017) 062079 doi:10.1088/1757-899X/263/6/062079

3. Results and discussion

The material used for both the suspension system is steel (ASTM A36). The stiffness used for both suspension systems is 58800 N/m, while the damping coefficient is taken to be 2586 N-s/m. The quarter car model is considered for the purpose of analysis. The sprung mass of the vehicle is 467 kg while the unsprung mass of the quarter car model is 21.2 kg. The above parameters were used for both the suspension systems i.e. Macpherson and Double wishbone suspension. These models along with the given specifications is analysed using ANSYS 15.0. The two suspension models are analysed for structural, modal, and transient analysis. The results of the analysis are discussed in the following sections.

3.1 Structural analysis with static loading

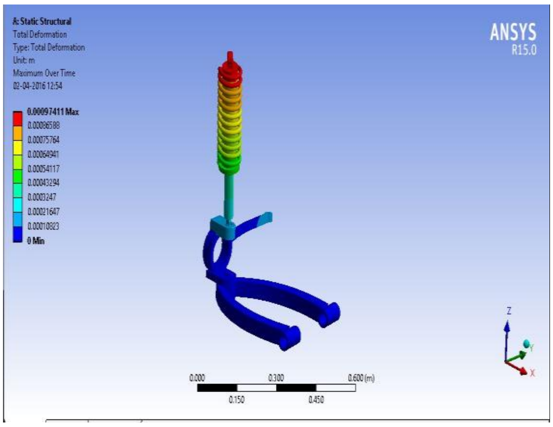

Figure 3. Static structural deformation of Macpherson suspension system

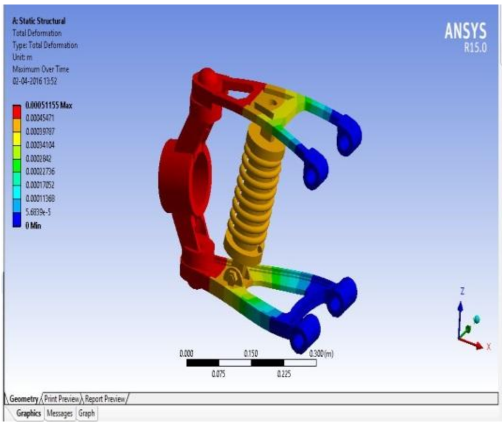

Figure 4. Static structural deformation of double wishbone suspension system

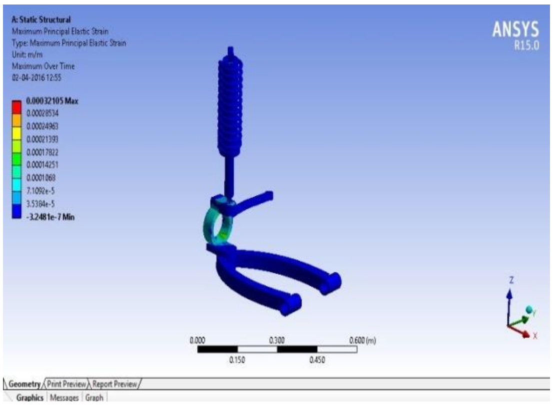

Figure 5. Static structural principal strain of Macpherson suspension system

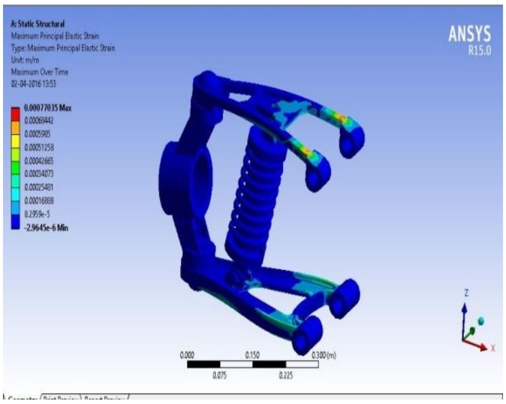

Figure 6. Static structural principal strain of double wishbone suspension system

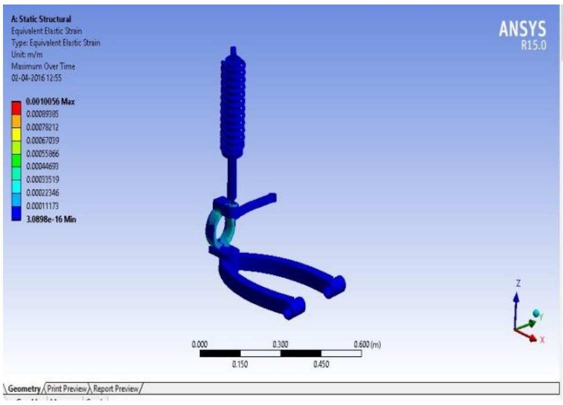

Figure 7. Static structural equivalent strain of Macpherson suspension system

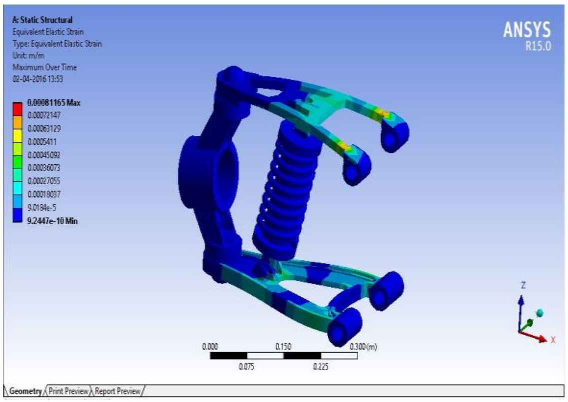

Figure 8. Static structural equivalent strain of double wishbone suspension system

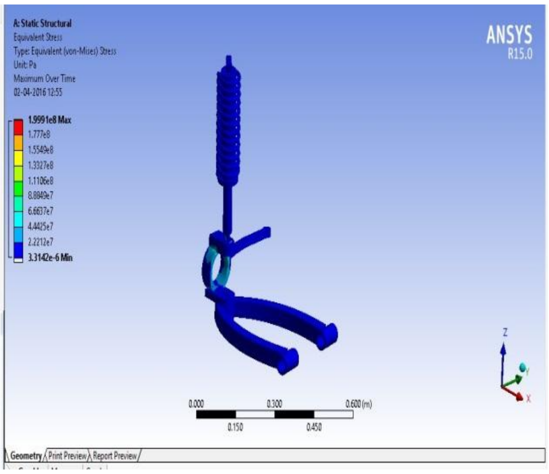

Figure 9. Static structural Von-Misses stress of Macpherson suspension system

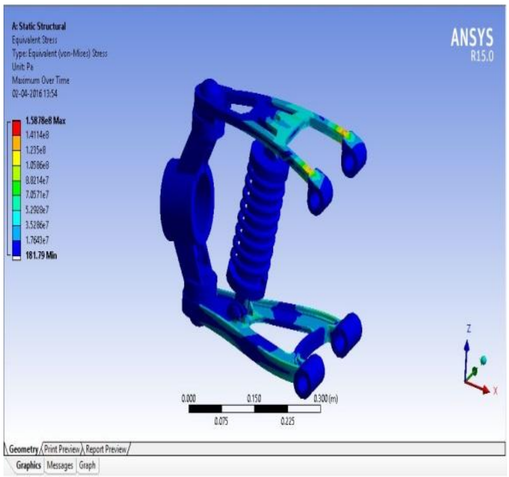

Figure 10. Static structural Von-Misses stress of double wishbone suspension system

Table 1. Comparison of static structural analysis between Macpherson and double wishbone suspension systems

Name	Macpherson Suspension	Double wishbone Suspension
Deformation (m)	0.0009471	0.00051155
Maximum Principal strain (m/m)	0.0003215	0.00077035
Equivalent Strain (m/m)	0.0010056	0.00081165
Von-Misses stress (N/m^2)	1.9991x10^8	1.5878x10^8

3.2 Structural analysis under dynamic loading:

IOP Conf. Series: Materials Science and Engineering **263** (2017) 062079 doi:10.1088/1757-899X/263/6/062079

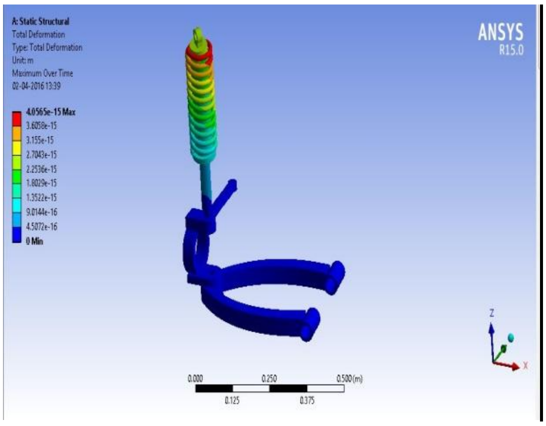

Figure 11. Static Structural deformation of Macpherson suspension system under dynamic loading

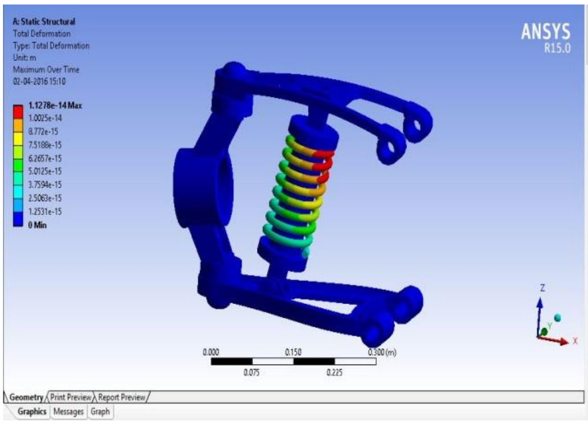

Figure 12. Static structural deformation of double wishbone suspension system under dynamic loading

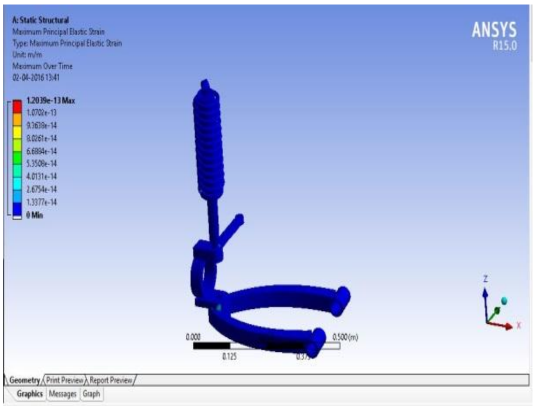

Figure 13. Static Structural principal strain of Macpherson suspension system under dynamic loading.

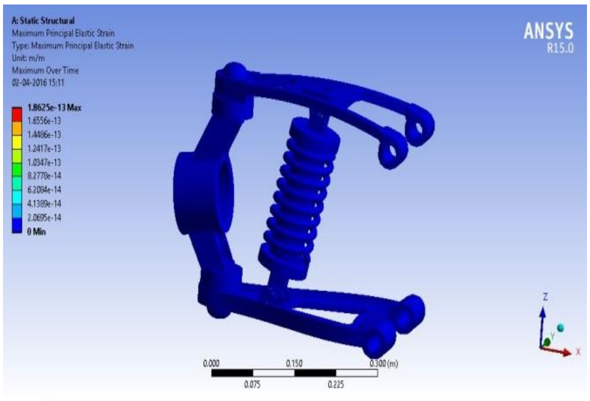

Figure 14. Static structural principal strain of double wishbone suspension system under dynamic loading.

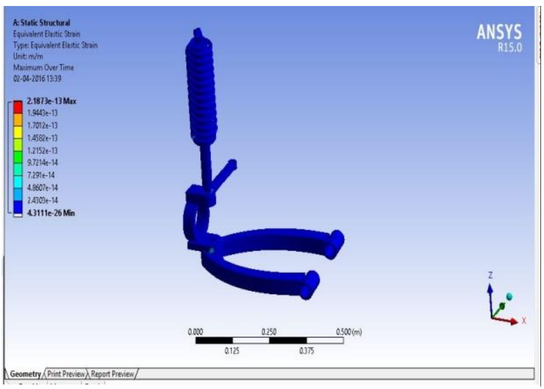

Figure 15. Static Structural equivalent strain of Macpherson suspension system

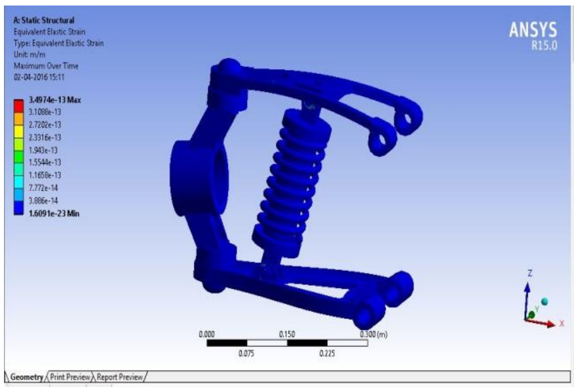

Figure 16. Static structural equivalent strain of double wishbone suspension system

under dynamic loading.

under dynamic loading.

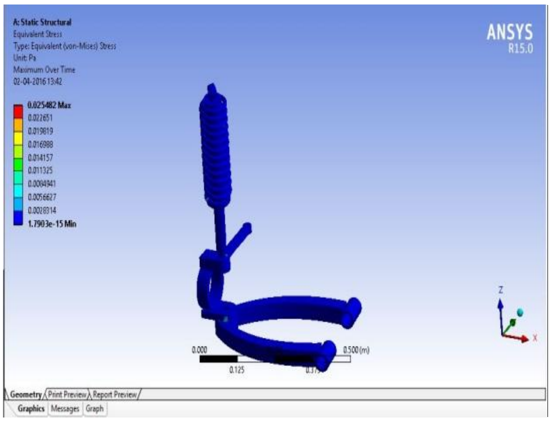

Figure 17. Static Structural Von-Misses stress of Macpherson suspension system under dynamic loading.

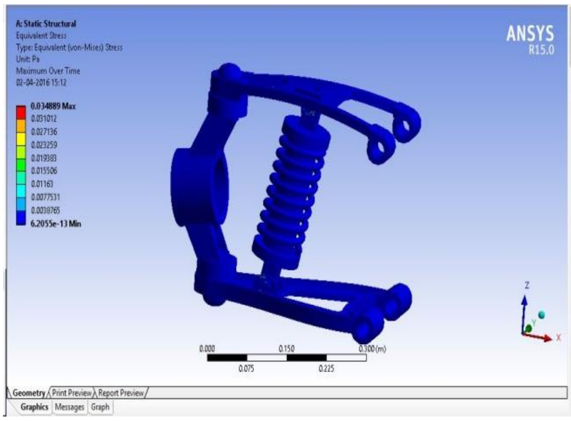

Figure 18. Static structural Von-Misses stress of double wishbone suspension system under dynamic loading.

Table 2. Comparison of static structural analysis under dynamic loading between Macpherson and double wishbone suspension systems

Name	Macpherson	Double wishbone
Deformation (m)	4.0565×10^{-15}	1.1278×10^{-14}
Maximum Principal strain (m/m)	1.2039×10^{-13}	1.8625×10^{-13}
Equivalent Strain (m/m)	2.1873×10^{-13}	3.4973×10^{-13}
Von-Misses stress (N/m^2)	0.025482	0.034889

3.3 Modal Analysis

Table 3. Comparison of freqeuncy values under modal analysis between Macpherson and double wishbone suspension systems

Mode number	Frequency (Hz) of Macpherson suspension	Frequency (Hz) of Double wishbone suspension
1	9.54	77.94
2	9.65	91.75
3	25.94	95.10
4	29.69	97.30
5	30.77	113.37

IOP Conf. Series: Materials Science and Engineering **263** (2017) 062079 doi:10.1088/1757-899X/263/6/062079

6	34.44	158.92

3.4 Transient Analysis

Macpherson Suspension Double wishbone Suspension

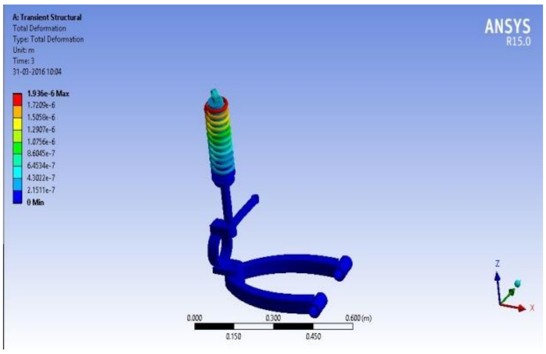

Figure 19. Transient analysis deformation of Macpherson suspension system

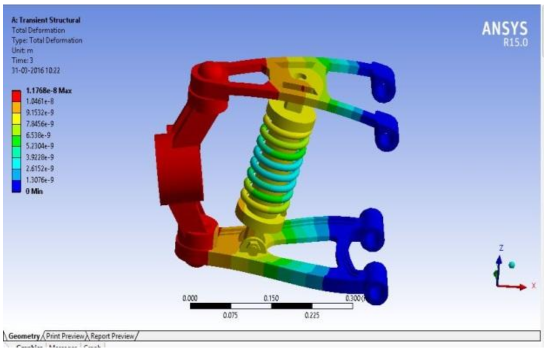

Figure 20. Transient analysis deformation of double wish bone suspension system

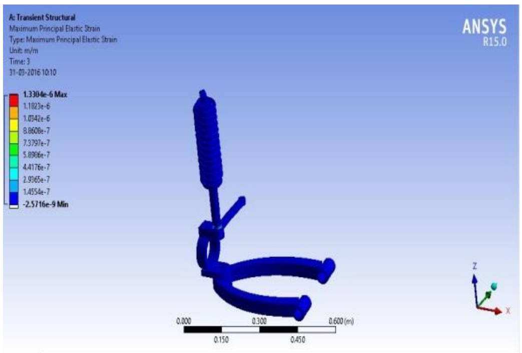

Figure 21. Transient analysis principal strain of Macpherson suspension system

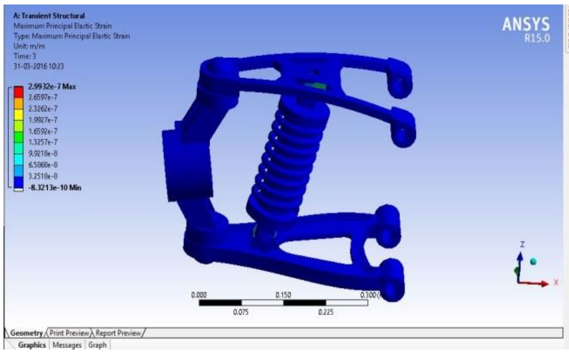

Figure 22. Transient analysis principal strain of double wishbone suspension system

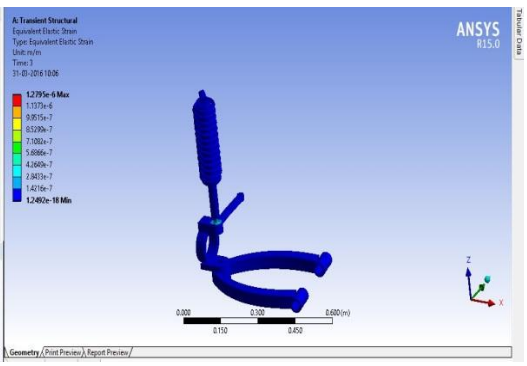

Figure 23. Transient analysis equivalent strain of Macpherson suspension system

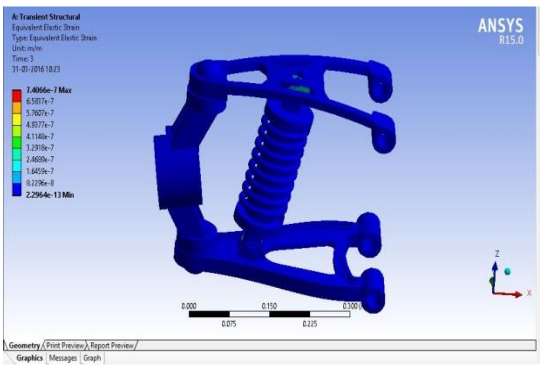

Figure 24. Transient analysis equivalent strain of double wishbone suspension system

IOP Conf. Series: Materials Science and Engineering **263** (2017) 062079 doi:10.1088/1757-899X/263/6/062079

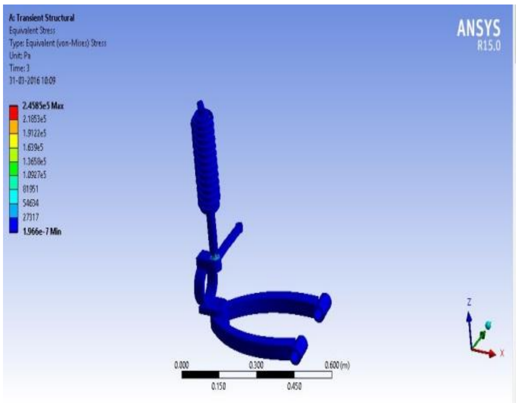

Figure 25. Transient analysis Von-Mises stress of Macpherson suspension system

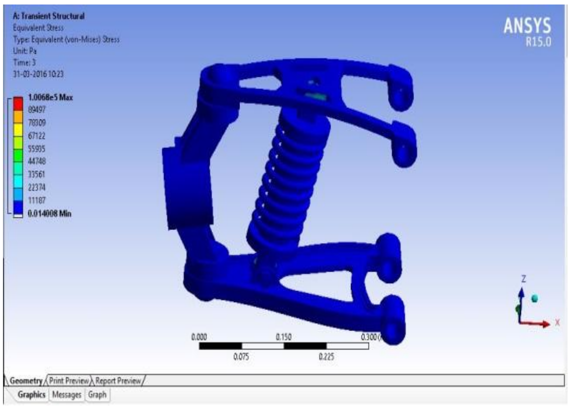

Figure 26. Transient analysis equivalent stress of double wishbone suspension system

Table 4. Comparison of transient analysis between Macpherson and double wishbone suspension systems

Name	Macpherson suspension	Double wishbone suspension
Deformation (m)	1.936 x 10^{-6}	1.1768 x 10^{-8}
Principal strain (m/m)	1.3304 x 10^{-6}	2.9932 x 10^{-7}
Equivalent Strain (m/m)	1.2795 x 10^{-6}	7.4066 x 10^{-7}
Von-Misses stress (N/m^2)	2.4585 x 10^{5}	1.0068 x 10^{5}

4. Conclusion

In the present work, a comparative study of two of the most used suspension systems viz. Macpherson and Double Wishbone suspension is done. The two suspension systems are compared on the basis of various analyses such as Structural analysis with static as well as dynamic loading along with Modal and Transient Analysis. The Structural analysis for static loading reveals that the double wishbone suspension induces lesser strain, stress (Von-Misses) and deformation values than the Macpherson suspension system. Although, the principle strains value is more in double wishbone suspension system than the latter. In case of structural analysis for dynamic loading, the Macpherson suspension comes off better than its counterpart. The natural frequencies for both the suspension systems were found using the Modal analysis and are shown in the results and discussion section. The result for transient analysis shows that the double wishbone performs better as it induces lesser stress, strain and deformation in the model.

IOP Conf. Series: Materials Science and Engineering **263** (2017) 062079 doi:10.1088/1757-899X/263/6/062079

References

[1] Liu J, Zhuang D J, Yu F and Lou L M 2008 *Optimized design for a Macpherson strut suspension with side load springs*, International Journal of Automotive Technology, **9**, 29-35.

[2] Purushotham A 2012 *Comparative Simulation studies on MacPherson Suspension System*, International Journal of Modern Engineering Research, **3**, 1377-1381.

[3] Vivekanandan N, Abhilash Gunaki, Chinmaya Acharya, Savio Gilbert and Rushikesh Bodake 2014 *Design analysis and simulation of Double wishbone suspension system*, International Journal of Mechanical Engineering, **2**, 1-7.

[4] http://mechanicalmania.blogspot.in/2011/08/comparison-between-macpherson-double-wishbone

[5] Rajput R K 2007 *A Textbook of Automobile Engineering*, Laxmi Publications, First edition.