International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 08 Issue: 07 | July 2021 www.irjet.net p-ISSN: 2395-0072

Vibration Analysis of a Heavy Duty Vehicle King-pin and the Study of its Effects on King-pin Life

Miss. Trupti Y. Galat[1], Prof. A. M. Shende[2]

[1]Trupti Yogeshwar Galat, Student of M.E. (Mechanical CAD/CAM) 2nd Yr, Jagadambha College of Engineering and Technology, Yavatmal, Maharashtra, India
[2]Anirudh M.Shende Assitant Professor of Mechanical Engineering Department, Jagadambha College of Engineering and Technology, Yavatmal, Maharashtra, India

---

Abstract - *Heavy duty vehicles always undergo to heavy loading and hard impacts while running. It often produces vibrations which are due to the bad road conditions, high engine speed or sudden jerks while running on road. Hence the produced vibrations may impact on the king-pin working and its life. We always measure the vibrations in terms of frequency and here the also the vibrating frequency is taken into consideration for entire study. The amount of maximum frequency produce in the king-pin and its assembly should not exceed the natural frequency of king-pin so that it will be safe.*

Also it is very important to have maximum natural frequency of king-pin to avoid its failure. But it's totally dependent on the metallurgy of king-pin and its flexibility. When the vibrating frequency reaches more than the natural frequency, there are the chances of failure. Slight increment of frequency will reach the harmonic frequency and at this frequency king-pin will get damaged. Failure of king-pin wills accurse at the resonance frequency which is slightly greater than the harmonic frequency value.

In this paper the vibration/Modal analysis of king-pin is carried out with the help of FEM tool (ANSYS 14.5) and studied for the failure chances of the king-pin. CAD model is prepared in CATIA V5R19 software and further converted into STEP format for importing into ANSYS software. Conclusive statement is written on the basis of vibration analysis results study.

Keywords: King-pin, Natural Frequency, FEM Tool, Resonance Frequency

1.INTRODUCTION

While no current-era automobile front suspension incorporates a physical kingpin, the axis defined by the steering knuckle pivot points acts a "virtual kingpin" about which the wheel turns. This virtual kingpin is inclined toward the centreline of the vehicle at an angle called the kingpin angle. Virtual or physical, the kingpin angle may also be referred to by its acronym KPA, kingpin inclination (KPI), or steering axis inclination (SAI), and remains a fundamental vehicle design parameter. On most modern designs, the kingpin angle is set relative to the vertical, as viewed from the front or back of the vehicle, and it is not adjustable, changing only if the wheel spindle or steering knuckles are bent.

The kingpin angle has an important effect on steering, making it tend to return to the straight ahead or centre position because the straight ahead position is where the suspended body of the vehicle is at its lowest point. Thus, the weight of the vehicle tends to rotate the wheel about the kingpin back to this position. The kingpin inclination also contributes to the scrub radius of the steered wheel, the distance between the centre of the tyre contact patch and where the kingpin axis intersects the ground. If these points coincide, the scrub radius is zero.

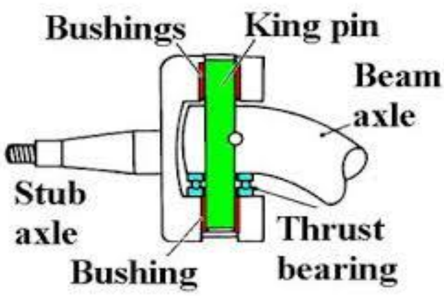

Figure 1: King Pin Location on Hob axle and beam axle

Figure 1 shows the king pin installed in between hub axle and beam axle. Bushings are attached on the hub axle for the hub movement. King pin is fixed on beam axle and bush is attached on both sides for proper turning. Thrust bearing is also attached on the king pin which protect king pin from damage while sudden shock is imposed on wheel.

1.1 . King-pin CAD Model

To prepare the CAD model of King-Pin few commands from sketcher module and part module are utilized. Figure 2 shows the CAD model of King-Pin, which is developed in CATIA v5R19 software. Circle, Rectangle, Axis etc commands from sketcher and pad, shaft, groove and fillet etc commands are utilized from part module. Height, Diameter, groove-depth are taken from reverse engineering process.

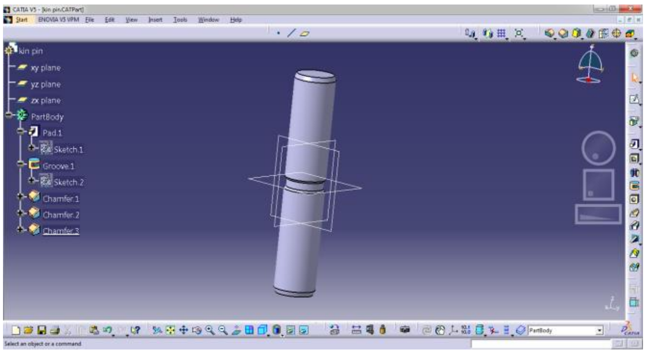

Figure 2: CAD model of King-Pin

1.2 Vibration Analysis of King-pin

Meshing of king-pin is one of the important procedure for performing vibration analysis. Figure 2 shows the meshed view of king-pin. It is simply the small solid pieces called elements which are connected with each other through some known points called as nodes. These elements are having identical shape. In this analysis 3D tetragonal element is used with 3mm maximum size. It is the primory step which always needs to perform to do any FEA analysis. Table 2 shows the total number of nodes and elements formed by meshing process.

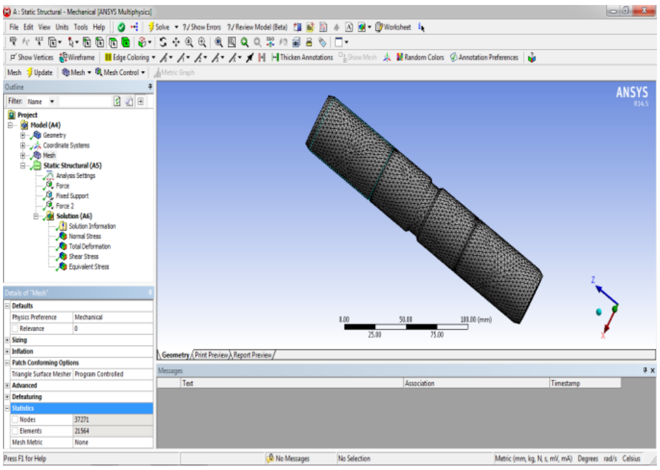

Figure 3: Meshed view of King-Pin

Type of Element	3D Tetragonal
No. of Elements	10954
No. of Nodes	20308

Table 2: Nodes and Elements

2. Material Used and its Properties

Table 1 shows the material properties used to perform vibration analysis. These properties varies material to material and 20MnCr5 is the alloy metal used for this analysis. King-pin is manufactured with this alloy metal.

Property	Value
Young's Modulus (E)	2.1e5 MPA
Poisson's Ratio (μ)	0.285
Density (ρ)	7865 kg/m^3

Table 1: Properties of 20MnCr5 for Structural Analysis.

3. Boundary Conditions

To simulate the proper physical condition, loads and fixed displacement are to be attached properly. In case of King-Pin, it is fixed at the centre of the pin where it actually comes in contact with axle bush. For this project King-Pin used in heavy duty vehicle like bus is considered. Hence the load which is to be applied on King-Pin is considered including thrust and torque. The total load applied in case of steering of wheel and torque applied is calculated by using formula. Hence the Actual Boundary Conditions are as follows.

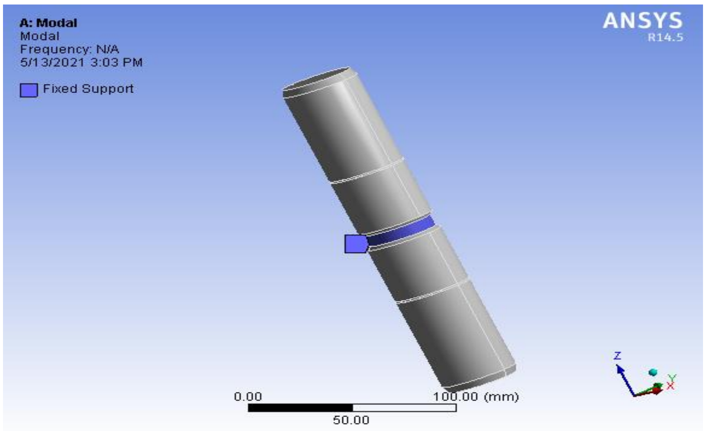

Figure 4: Boundary Conditions applied on King-Pin for Vibration

4. Result Analysis

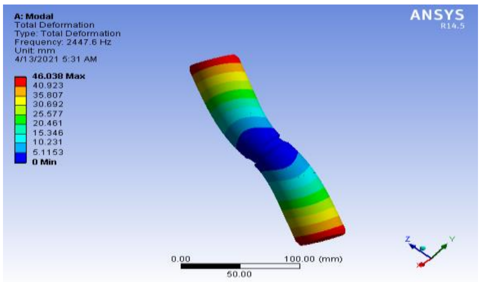

Figure 5: Deformation in Mode

Figure 5 shows the first mode of vibration where the maximum possible deformation is 46 mm at 2447 Hz. This frequency is very high and not achievable in any condition by the vehicle. Also we know that, such high deformation is not possible as it is located inside the shackle or hub. These vibrations will be absorbed by the attached vehicle parts.

Higher the frequency, safer the object is the main theme of vibration analysis. Reaching till 6th mode of vibration, natural frequency crosses 8000Hz. Hence King-Pin is safer than any other part in suspension system.

Sr. No.	Frequency (Hz)	Total Deformation (mm)
1	2447	46
2	2450	46
3	2531	46
4	2533	46
5	7947	46
6	8008	46

Table3: Tabulated Results for Vibration Analysis

5. CONCLUSION

By observing analysis results, it is clear that the natural frequency of king-pin is very high (8008 Hz) which much capable to sustain any vibrations which could be generated in heavy duty vehicle. The entire frequency mode has sufficient frequency value. Also the deformation value is large and achieving this deformation is not possible. Hence the king-pin is safe from vibrations generated in heavy duty vehicle. The king-pin is having required flexibility and vibrations do not affect the life of king-pin.

REFERENCES

[1]Pravin R. Ahire1, Prof. K. H. Munde2, "Design and analysis of front axle for heavy commercial vehicle". International Journal Of Engineering And Computer Science ISSN: 2319-7242 Volume 5 Issues 7 July 2016, Page No. 17333-17337

[2]Hemant L. Aghav, "Life Prediction for Vertical and Braking loading of Front Axle of Heavy-Duty Truck". International Journal of Engineering Science and Computing, July 2016 8207 http://ijesc.org/, DOI 10.4010/2016.1915, ISSN 2321 3361 © 2016 IJESC, Volume 6 Issue No. 7

[3]Amol A. Sangule1, Prof. Mane S. S.2, Prof. Dalwe D.M, "Modeling, Analysis and optimization Front Axle of Alto Maruti-800 LMV Car for Weight Reduction". International Journal for Research in Applied Science & Engineering Technology (IJRASET), ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 6.887, Volume 7 Issue IV, Apr 2019- Available at www.ijraset.com

[4]Kiran Maddewad1, Trupti Jadhav2, Ajinkya Bhosale3, "Optimization of Front Axle for Heavy Commercial Vehicle by Analytical and FEA Method". International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395 -0056 Volume: 04 Issue: 03 | Mar -2017 www.irjet.net p-ISSN: 2395-0072

[5]1Vinay Dilliwar, 2Sankalp Verma, "Modification of Manufacturing Process of Kingpin for Steering Assembly of Heavy Motor Vehicles and its Analysis". 2020 JETIR July 2020, Volume 7, Issue 7 www.jetir.org (ISSN-2349-5162)

[6]J.B. Marcomini1*, C.A.R.P. Baptista2, J.P. Pascon3, "Failure Analysis of a Hot Forged SAE 4140 Steel Kingpin". International Journal of Engineering Research & Science (IJOER) ISSN: [2395-6992] [Vol-2, Issue-6 June- 2016]

[7]1Pathan Tausif H, 2Prof. D. B. Jani and 3Prof. Kiran Bhabhor, "Analysis of Front Axle for TATA LPT 1109 EX36 by Analytical and FEA Method". IJARST, ISSN (Online) 2581-9429, International Journal of Advanced Research in Science & Technology (IJARST), Volume 2, Issue 3, June 2020

[8]Dinesh Babu S.1, Farug H.2, Tanmay Mukherjee3, "Design & Analysis of Steering System for a Formula Student Car". ISSN (Online): 2319-8753, ISSN(Print) : 2347 – 6710, International Journal of Innovative Research in Science, Engineering and Technology, An ISO 3297: 2007 Certified Organization Volume 6, Special Issue 7, April 2017

[9]Yung-Chang Chen, Hsing-Hui Huang, Ching-Hsu Hsieh and Jia-Bin Lin, "Determination of Kingpin Axis from Wheel Points Using Dual Quaternion Analysis". Proceedings of the World Congress on Engineering 2011 Vol III WCE 2011, July 6 - 8, 2011, London, U.K.

[10]Shpetim Lajqi, 2. Stanislav Pehan, 3. Naser Lajqi, "Design of Independent Suspension Mechanism for a Terrain Vehicle with Four Wheels Drive and Four Wheels Steering". Faculty Of Engineering - Hunedoara, Romania, Annals Of Faculty Engineering Hunedoara – International Journal Of Engineering

[11]Arun Singh *, Abhishek Kumar, Rajiv Chaudhary, R. C. Singh, "Study of 4 Wheel Steering Systems to Reduce Turning Radius and Increase Stability". ISBN 978-93-5156-328-0 International Conference of Advance Research and Innovation (ICARI-2014)

[12] C.Radhakrishnan1, Azhagendran.K 2, Mohanlal.K3, "Design and Analysis of Automotive Shackle". IJISET - International Journal of Innovative Science, Engineering & Technology, Vol. 2 Issue 5, May 2015. www.ijiset.com, ISSN 2348 – 7968

[13]Andrew S.Ansara, Andrew M.William, "Optimization of Front Suspension and Steering Parameters of an Off-road Car using Adams/Car Simulation". Department of Mechanical Engineering, Alexandria University, Alexandria, Egypt, International Journal of Engineering Research & Technology (IJERT), http://www.ijert.org ISSN: 2278-0181, IJERTV6IS090055, www.ijert.org, Vol. 6 Issue 09, September - 2017

[14]Sagar Jambukara and Sujatha Cb, "Study of the Effects of Caster Offset and King-Pin Offset on Kinematics and Lateral Dynamics of Long Wheelbase Solid Axle Bus". Indian Institute of Technology Madras, Chennai, India, Proceedings of the 19th International and 14th European-African Regional Conference of the ISTVS, Budapest, September 25–27, 2017, https://www.researchgate.net/publication/327792176

[15]Marek Jaśkiewicz1, Jakub Lisiecki2, "Facility for performance testing of power transmission units". Scientific Journals Zeszyty Naukowe of the Maritime University of Szczecin Akademii Morskiej w Szczecinie, 2015, 42 (114), 14–25, ISSN 1733-8670 (Printed) ISSN 2392-0378 (Online)

BIOGRAPHIES

Trupti Yogeshwar Galat
Pursuing M.E (CAD/CAM)
J.C.O.E.T Yavatmal

Anirudh M. Shende
Assistant Professor of J.C.O.E.T
Yavatmal