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Performance Analysis of Heavy Duty Vehicle King-Pin Using CAD Tool

[1]Miss. Trupti Yogeshwar Galat (M.E. Student), [2]Prof. A. M. Shende
*[*1]Department of Mechanical Engineering, Jagdambha College of Engineering and Technology, Yavatmal*
[2] Department of Mechanical Engineering, Jagdambha College of Engineering and Technology, Yavatmal

Abstract
King-Pin plays an important role in steering, suspension and stability mechanism of any heavy duty vehicle like truck, bus, containers etc. Tyre inclination angles are set with respect to King-Pin only, which directly affect tyre life. King-Pin is a connecting media between excel and wheel. Turning of wheels, balancing etc. are the important functions of King-Pin.

As it needs to work in tough conditions hence it is made up with tough metals like high carbon steel, chromium steel etc. Still there are few issues with the life of pin and improper lubrication of King-Pin bushings can cause King-Pin contact points to begin to wear at the steering knuckle. You will notice signs of King-Pin and bushing failure from incorrect vehicle alignment, premature and uneven front tire wear, and rough handling. Experiencing these symptoms while driving may result in a shaking cab or steering wheel. Because of the potential for further damage and operator safety risks, properly diagnosing and repairing worn King-Pins, bushings and tie rods needs to be addressed promptly.

In this paper the King-Pin is to be redesigned and strength performance is to be carried out by using manual calculation method and CAD/CAE tools. In manual calculation method the all design parameters are inspected and redesign of King-Pin is done with proper designing formulas. CAD model is developed by using reverse engineering process and further strength performance is carried out on CAD model in CAE tool like ANSYS 14.5. Also the role of vibration is to be checked. By studying all generated results conclusion will be drawn.

Keywords: *Strength performance, CAD/CAE Tool, ANSYS 14.5, King-Pin*

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I. HEAVY DUTY FRONT AXLE KING-PIN

The King-Pin angle has an important effect on steering, making it tends 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 King-Pin back to this position. The King-Pin inclination also contributes to the scrub radius of the steered wheel, the distance between the centre of the tyre contact patch and where the King-Pin axis intersects the ground. If these points coincide, the scrub radius is zero.

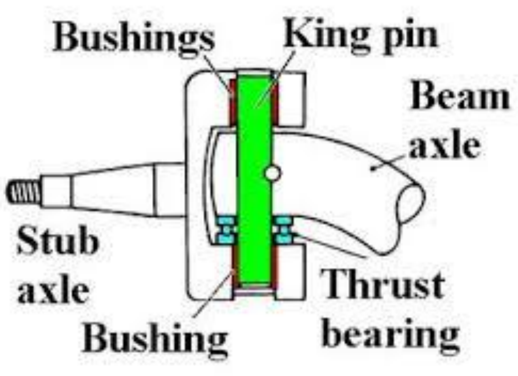

Figure 1: King-Pin Location on Hob axle and beam axle

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

II. CAD MODELLING OF KING-PIN

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 utilised from part module. Height, Diameter, groove-depth are taken from reverse engineering process.

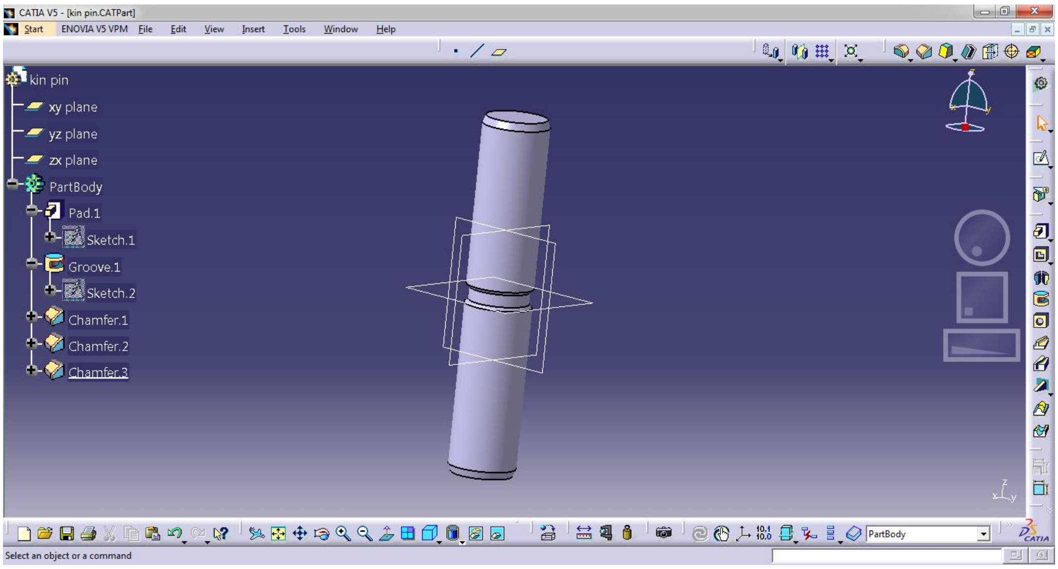

Figure 2: CAD model of King-Pin

III. STRUCTURAL ANALYSIS OF KINGPIN

3.1 Discretization/Meshing refers to the process of translating the material domain of an object-based model into an analytical model suitable for analysis. In structural analysis, discretization may involve either of two basic analytical-model types.

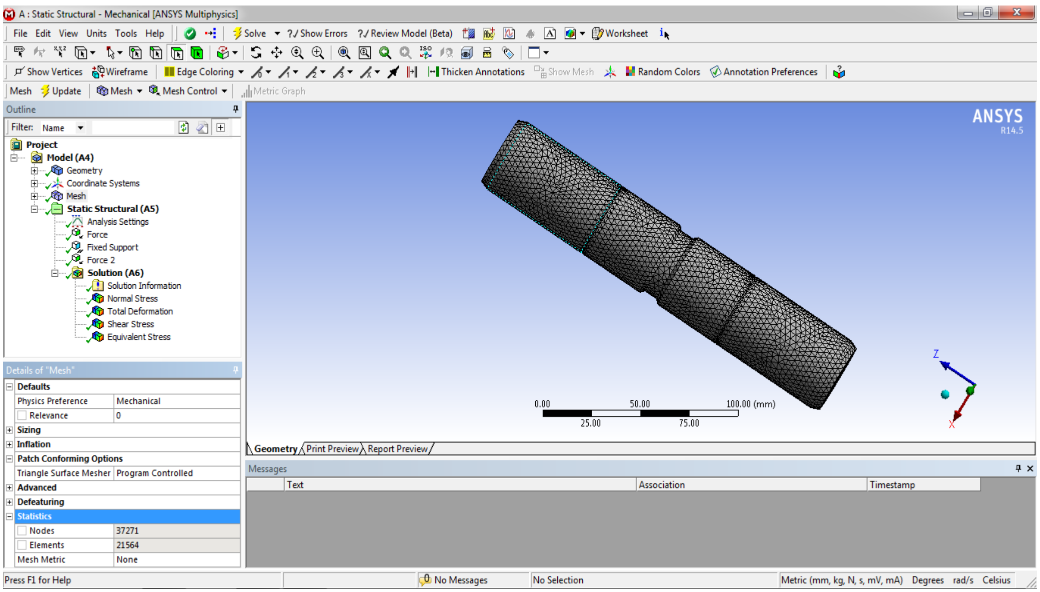

Figure 3: Meshed view of King-Pin

Table 1: Nodes and Elements

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

3.2 Material Properties Required

Young's Modulus, Poisson's Ratio and Density are three most important properties we need to perform structural Analysis of any mechanical component.

Table 2: Properties of 20MnCr5 for Structural Analysis.

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

3.3 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, which is explained Chapter 6. Hence the Actual Boundary Conditions are as follows.

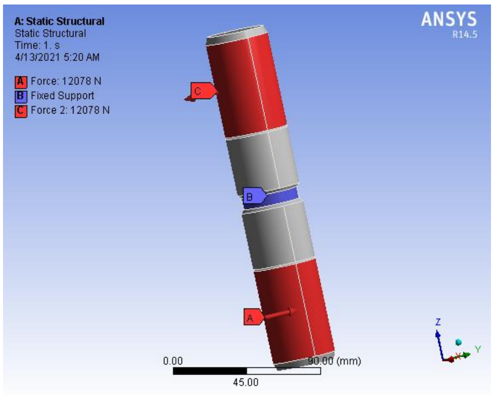

Figure 4: Boundary Conditions applied on King-Pin for structural analysis.

3.4 Steps to Perform Structural Analysis

To perform structural analysis of King-Pin, following steps are to be performed.

Step 1: Open ANSYS Workbench 14.5 Software and select structural analysis option from analysis setting menu.
Step 2: Set material Properties in engineering data module for King-Pin.
Step 3: Import .igs format file of King-Pin into design modeler module.
Step 4: Apply material property to imported King-Pin geometry.
Step 5: Perform Meshing operation in model module. This process is also called as descretization/Meshing process.
Step 6: Apply Boundary Conditions on King-Pin.
Step 7: Select required result type from solution menu.
Step 8: Solve the analysis.
Step 9: Save required Results.

3.5 Structural Analysis Results

By performing Structural Analysis following results are obtained. Figure 5 shows the total deformation by the application of structural load as shown in boundary conditions. It is observed that the maximum deformation is 0.1203 mm only. This deformation is having acceptable range. Also at the end only maximum deformation accurse. Remaining King-Pin body having minute deformation.

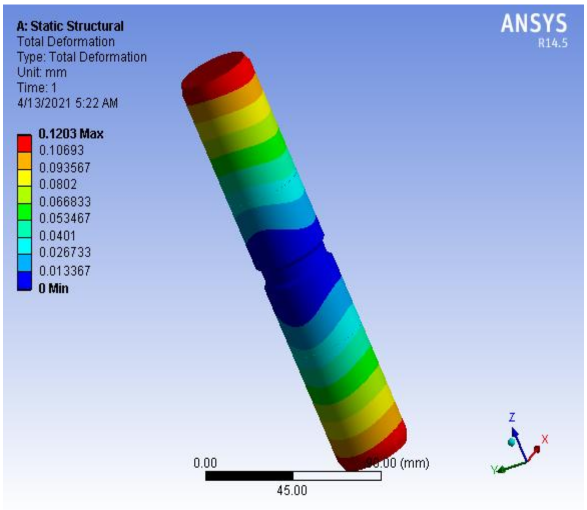

Figure 5: Total Deformation obtained in Structural Analysis.

Figure 6 shows the Equivalent stresses obtained in structural analysis of the King-Pin. We have used 20MnCr5 material and maximum stresses found at the fixed position. 300 MPA stresses are in acceptable range. Also the remaining King-Pin body portion is in blue colour which shows the minimum stress value.

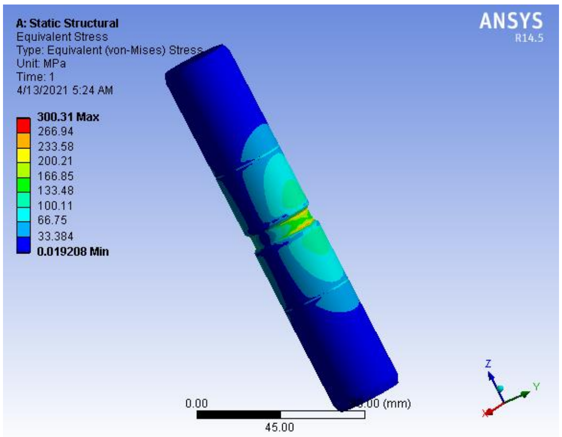

Figure 6: Equivalent Stresses developed in King-Pin

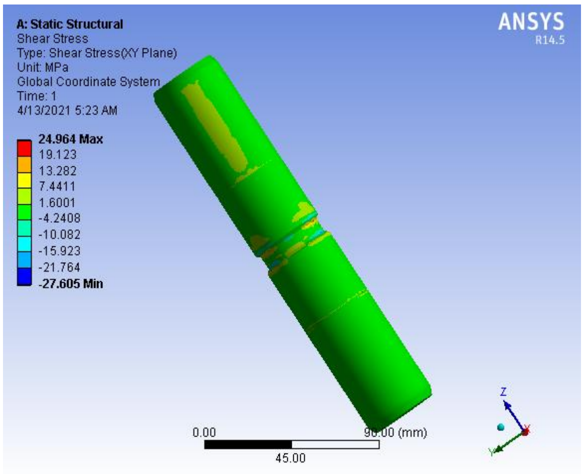

Figure 7: Shear Stresses developed in King-Pin

Above Figure 7 shows the shear stresses developed in King-Pin. These stresses are very less. At the centre of pin, where it is fixed, the maximum stresses (24MPA) accurse.

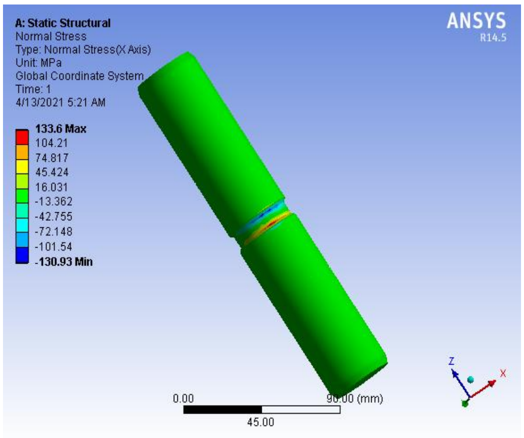

Figure 8: Normal Stresses developed in King-Pin

Figure 8 shows the Normal stresses in structural analysis. The maximum stresses and minimum stresses are at the centre of the King-Pin. It has 133 MPA value. This value also has a safe limit.

By observing all the values in structural analysis result, it is found that all values do not damage the King-Pin. Also the application of such load regularly will not affect the King-Pin life.

IV. CONCLUSION

By studying all results generated by analysis, it is found that the normal working load will not damage the King-Pin. Hence King-Pin can be damaged/failed by only two conditions.

1) Wear due to continuous running and jerks leads the scratches on the King-Pin surface which create play. Hence due to play King-Pin may fail.

2) Sudden large shock or jerk will cause the failure of King-Pin. This shock will have more force which may be the reason of crack in King-Pin structure.

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)