International Journal of Research in Engineering and Science (IJRES)
ISSN (Online): 2320-9364, ISSN (Print): 2320-9356
www.ijres.org Volume 9 Issue 5 ǁ 2021 ǁ PP. 67-70

A review on Failure Analysis of Heavy Duty Vehicle King-Pin Attached on Front Axle

[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 is a connecting member between tyre and axle. It also provides support to the shock-absorber system. It always undergoes the large number of stresses during vehicle running. Sudden jerks on the road will impact directly on the King-Pin. Hence the metal used to manufacture the King-Pin is having much strength. But still it is observed that some of the King-Pins are fails before its designed life. This may be due to unusual road conditions. Therefore there is need of deep study of stresses developed on the 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 available literature on the King-Pin are reviewed and studied well to understand the various stress related problems which are associated with King-Pin life.
Keywords: *King-Pin, stress, operator safety risk*

Date of Submission: 27-04-2021 Date of acceptance: 11-05-2021

I. RESEARCH DOMAIN

King-Pin is the component of steering system used in vehicles to steer, control and used to provide stability to vehicle by means of axle and wheel spindle connector. It is designed in such a way that it should sustain major jerks, lodgings and sudden impact which directly transmit through the wheel. It is a rigid shaft which holds the load of vehicle comes on wheel. It is available in different shapes and sizes along with the different materials as per the type of vehicle.

There are several research studies are available to understand the failure of King-Pin. Major factors which lead the failure are the sudden jerks and unbalanced wheels which lead play in King-Pin. If play accurse in King-Pin joints, the wear takes place and King-Pin get failed before its designed working period.

II. LITERATURE SURVEY

Pravin R.Ahire[1], Prof. K. H. Munde[2], "Design and analysis of front axle for heavy commercial vehicle". Their paper deals with design and analysis of front axle. The same analysis with help of FE results were compared with analytical design. For which paper has been divided in to two steps. In the first step front axle was design by analytical method. For this vehicle specification – its gross weight, payload capacity, braking torque used for subject to matter to find the principle stresses & deflection in the beam has been used. In the second step front axle were modelled in CAD software & analysis in ANSYS software. [1]

Hemant L. Aghav, "Life Prediction for Vertical and Braking loading of Front Axle of Heavy-Duty Truck". Aim of their study is to find stress analysis and predict life of front axle for vertical and braking loading case using analytical, experimental and FEA method. The fatigue life of front axle is estimated by strain life approach method. Here, Coffin-Manson and Smith Watson Topper equations used for calculating the fatigue of front axle beam. Stress analysis is performed by ANSYS workbench and fatigue analysis is performed by NCODE design life software under vertical and braking loading, and results are compared with the experimental test. Fatigue life of axle obtained by analytical method is more than 4 x 103, which is considered as safe for vertical loading case, and the same is validated by FEA method. Stresses occurred in the axle are very high for braking loading case, so life of axle is also very low as compared to other loading condition i.e. vertical and cornering case. The location of Fatigue failure for vertical and braking loading obtained is in the goose neck of axle due to highest stress of that region. [2]

Amol A. Sangule[1], Prof. Mane S. S.[2], "Modeling, Analysis and optimization Front Axle of Alto Maruti-800 LMV Car for Weight Reduction". The Front Axle is most important part in load carrying vehicle. The failure of Front Axle is serious concern to vehicle and thus for human life. So it is necessary to analyze the axle ability to withstand typical service loading which develops stress in the axel resulting into failure. Further the objective of analysis is to improve its product quality while reducing development time, material and manufacturing costs while maintaining the stress levels. In this paper for Analysis front axle of Alto Maruti-800 LMV Car used. The objective of the project is to analysis and optimization the front axel for reducing weight. [3]

Kiran Maddewad[1], Trupti Jadhav[2], "Optimization of Front Axle for Heavy Commercial Vehicle by Analytical and FEA Method". Their paper focuses on design, analysis and optimization of front axle. The approach in this research paper has been divided into two steps. The First step involves design of front axle by Analytical method. For this, the vehicle specification gross weight and payload capacity is used to determine the stress and deflection in the beam. Second step involved further modeling of front axle using CATIA-V5 and ANSYS software. For model optimization, FEA results were compared with analytical design. [4]

Vinay Dilliwar[1], Sankalp Verma[2], "Modification of Manufacturing Process of Kingpin for Steering Assembly of Heavy Motor Vehicles and its Analysis". Conventional design of kingpin comes with a cross hole in the center of pin. But when the vehicle got loaded and travelled across hilly areas it was found that vehicle developed field failure from the center of kingpin. This was due to low core hardness required in the cross-hole area. In the proposed design this cross hole is eliminated which was used only for greasing. By eliminating this cross-hole manufacturing cost also got reduced and improved lead of manufacturing also. New kingpin without cross-hole is manufactured using standard manufacturing techniques which includes process flow diagrams and PFMEA. Nondestructive testing of new design of kingpin is also conducted using MPI testing. [5]

J.B. Marcomini[1], C.A.R.P. Baptista[2], "Failure Analysis of a Hot Forged SAE 4140 Steel Kingpin". The fifth wheel and kingpin connection system, a critical part of heavy vehicles, provides the link of tractor and trailer. The kingpin is usually manufactured by hot forging. A part manufactured by this process was assembled in a fifth wheel of an off-road truck and presented an early failure. The truck was used in a quarry until the kingpin failure, three months later. One process issue that can occur in hot forged products is a poor grain structure due to overheating, burning and cavitation. The Scanning Electron Microscopy (SEM) analysis of the failed part showed the presence of cavitation. However, the failure analysis results evinced that cavitation was not the main cause of the fracture, but a combination of wear, impact fatigue and overload. [6]

Pathan Tausif H[1], Prof. D. B. Jani[2], "Analysis of Front Axle for TATA LPT 1109 EX36 by Analytical and FEA Method". Front axle is the most essential part especially in a load carrying vehicle. The strength of front axle is a serious concern in commercial vehicle so, it is necessary to analyze the front axle that able to withstand at severe load conditions. Hence proper design of the front axle beam is extremely crucial. In present research work design of the front axle for TATA LPT 1109 EX36 heavy commercial vehicle were done. Material selection is crucial step for manufacturing. This is to analyze the front axle with different material such as AISI 4130, AISI 4140, and AISI 1020, 27C15 and gray cast iron and also changing geometry of front axle. The approach in this project has been dividing into two steps. In the first step front axle was design by analytical method. As the vertical loads are applied on the PAD spring which gives major support for front axle. The analysis is carried out to the vertical loads where total weight is carried out by the vehicle in order to find the stresses and deflection in the beam has been used. In the second step front axle were modeled in solid works and the model was solved in ANSYS software and FEA results compare with analytical solution. [7]

Dinesh Babu S.[1], Farug H.[2], "Design & Analysis of Steering System for a Formula Student Car". The aim their study is to design a simple yet effective steering system that reduces driver effort and also adapts to the track conditions offered such that the system does not fail causing harm to both the car and also the driver. A mathematical model is set up followed by geometrical validation and modelling of the entire steering system using CAD software SolidWorks and CATIA V5. Since like any other mechanical system stress is generated in the system, Static analysis is performed using ANSYS Workbench to check the static stress distribution. To ensure the dynamic response of the steering system Multi Body Dynamics (MBD) analysis is performed using Altair Hyperworks. [8]

Yung-Chang Chen, Hsing-Hui Huang, "Determination of Kingpin Axis from Wheel Points Using Dual Quaternion Analysis". Their study aims to present a dual quaternion analysis (DQA) method for calculating the kingpin axis geometry. The corresponding parameters include the caster angle, SAI angle, toe angle, caster trail and scrub radius. An ADAMS/Car simulation model for the strut-SLA suspension is employed to assess the efficiency of the proposed method. Two distinctive marker sets and the marker coordinates are extracted from the kinematic model. In addition, the finite screw axis (FSA) method is employed for purposes of comparison with the DQA method. The results reveal that the marker distribution has a significant effect on calculating the position of the screw axis. In contrast to the FSA method, the DQA analysis is immune to any singularities because it enables the simultaneous matrix of rotation and translation. Thus, the proposed method is suitable for determining the kingpin axis and its related parameters in a K&C test. [9]

Shpetim LAJQI[1], Stanislav PEHAN[2], "Design of Independent Suspension Mechanism for a Terrain Vehicle with Four Wheels Drive and Four Wheels Steering". In their paper a terrain vehicle with four wheels drive and four wheels steer intended to use for recreational purpose is presented. The main purpose is to design the suspension mechanism that fulfills requirements about stability, safety and maneuverability. Research is focused to do a comprehensive study of different available independent suspension system (MacPherson, double wishbone, multi-link) and hence forth develop a methodology to design the suspension system for a terrain vehicle. Few chosen suspension systems are analyzed into the very details in order to find out the optimal design of it. During development process of the suspension system should be considered design constraints and requirements provided in the check list. Afterwards the simulation results for kinematics analyses of suspension mechanism are performed in Working Model 2D and MATLAB environments. Achieved results are discussed in detail in order to find the best solution that will fulfill pretentious requirement from developed suspension system. All these investigations and reviews related to the suspension system will be exploited in order to obtain the optimal suspension geometry to equip a terrain vehicle, with such system. [10]

Arun Singh[1], Abhishek Kumar[2], "Study of 4 Wheel Steering Systems to Reduce Turning Radius and Increase Stability". In their study report, the performance of four wheels steered vehicle model is considered which is optimally controlled during a lane change maneuver in three type of condition which is low speed maneuver, medium speed maneuver and high speed maneuver. Four-Wheel Steering – Rear Wheels Control. For parking and low-speed maneuvers, the rear Wheel steer in the opposite direction of the front wheels, allowing much sharper turns. At higher speeds, the rest wheels steer in the same direction as the front wheels. The result is more stability and less body lean during fast lane changes and turns because the front wheels don't have to drag non-steering rear wheels onto the path. [11]

C.Radhakrishnan[1], Azhagendran. K, "Design and Analysis of Automotive Shackle". Shackle as a part of suspension system, this help to enhance the leaf spring flexibility. The arrangement tends to tensile, bending, shear and proof loads. This will cause the failure of suspensions system. Finite element analysis (FEA) is carried out at static condition of the shackle, so that stress distribution can be observed for analysis of high stress zones. Solid works model is carried out in the analysis. The analysis is to compare the various loading condition and the overall stress distribution zones have been studied. [12]

Andrew S.Ansara, Andrew M.William, "Optimization of Front Suspension and Steering Parameters of an Off-road Car using Adams/Car Simulation". The design of an off-road vehicle is very complicated as the car is subjected to very harsh conditions and it can fail easily causing a lot of damage if it isn't designed well. One of the most important parameters affecting the car's performance is the suspension and steering systems design as it affects the vehicle's performance in handling, during breaking and cornering, the tires contact with the ground, the forces acting on the vehicle's chassis and it also affects the driver's comfort during the ride. So given all that we need to pay a lot of attention to designing a set up where all the systems harmoniously work together to give the optimum performance that can allow to vehicle to operate with maximum safety, stability and reliability. [13]

Sagar Jambukara and Sujatha Cb, "Study of the Effects of Caster Offset and Kingpin Offset on Kinematics and Lateral Dynamics of Long Wheelbase Solid Axle Bus". Their study was to understand the effects of varying caster offset and kingpin offset on a long wheelbase bus and therefore an open loop study was conducted for the same. Handling response metrics were evaluated for three different manoeuvres, namely straight path driving, steady state circles and double lane change. The handling response metrics analysed include diameter of turn, tyre side-slip angles, body slip angle, yaw angle, yaw rate, chassis roll and forces at tyre road contact. A 2-variable (caster offset and kingpin offset) and 5-level design of experiments (DOE) was carried out using the full factorial matrix to determine the effects of the parameters on the above-mentioned handling metrics. The results show that both caster offset and kingpin offset have noteworthy influence on the kinematics and dynamics of the bus and hence their real-time control could be possibly considered for further improvement of handling performance. [14]

Marek Jaśkiewicz, Jakub Lisiecki, "Facility for performance testing of power transmission units". Their study describes the engineering design for a facility to test the performance of gearboxes and drive axles. Power transmission units are much more frequently tested on test rigs than in motor vehicles. The rig testing of such devices constitutes a very complex area because of the diversity of functions performed by individual components and their parts in the power transmission systems of motor vehicles and construction machinery. In the simulation tests carried out on simulation test rigs, the conditions of testing of individual units should match the expected conditions of operation for such units as much as possible. The test rigs used for this purpose are very complicated and expensive, but the results of rig tests are more reliable and accurate than they would be if other test methods were employed. The rig tests described here reflect the impact of anticipated service loads on the endurance of the unit under test. [15]

III. CONCLUSION

By studying all above research and papers following conclusions are drawn.

1) Very less study material is available on King-Pin and its failure.
2) Authors have focused on entire steering and suspension system, whereas the separate attention is needed on King-Pin.
3) Material change can also give better results in case of King-Pin failure.
4) It is observed that the vibrations are also responsible for failure; hence large scope is available to study vibrations on King-Pin.
5) King-Pin failure or brake accurse when sudden jerk or sudden impingement of load accurse and fails if play develops in King-Pin joint.

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)