Review on Front Axle Kingpin of Automobiles

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Abstract— Kingpins are used in various steering systems to automobiles front axle. The current work studies the various researches conducted in optimizing design and material of front axle using numerical and experimental techniques to minimize vibration, fatigue failure and improve strength. The study also includes manufacturing process involved, stresses generated using FEA software in analysis of structural behaviour of front axle.

Keywords: Kingpin, Structural Analysis, Front Axle

I. INTRODUCTION

The *kingpin*, is the main pivot in the steering mechanism of a *car* or other *vehicle*. The suspension design is crucial in the development of vehicle behaviour to optimize vehicle performance, handling and comfort. There are a multitude of possible adjustments depending on the vehicle (comfort, sportiness, etc.). These settings play a important role in passengers safety in all phases of driving. The design of the steering system plays a vital role in stability and control of an automobile. There are three main parameters to be optimized for this regard, namely camber, caster and toe angles. Among these three, the camber angle plays a predominant role in vehicle control. If a car has a high negative camber angle, it is more stable. But high camber angle values are required only in some extreme cases like high speeds or emergency maneuvering.

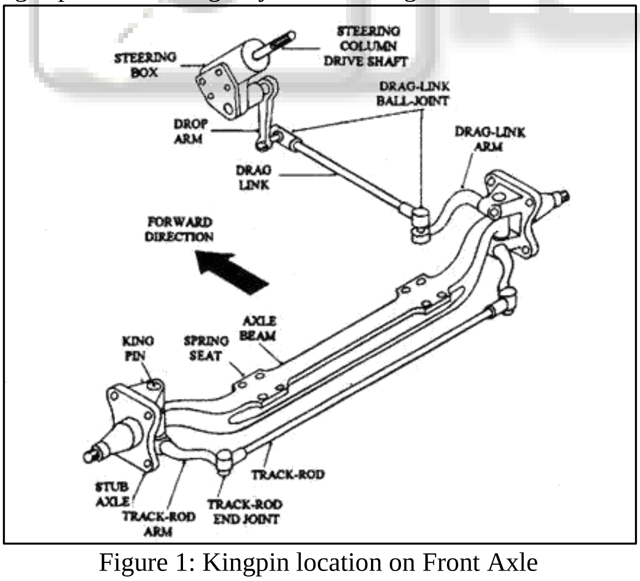

Figure 1: Kingpin location on Front Axle

II. LITERATURE REVIEW

Zuo et. al. [1] has been working for the design of a single degree-of-freedom (SDOF) absorber to damp SDOF vibration and efficient numerical systems. When the vehicle is not in motion, the only job that the axle has to do is hold the wheels in proper alignment and support part of the weight. When the vehicle goes into motion, the axle receives the twisting stresses of driving and braking.

Sanjay Aloni et al. [2] "Comparative evaluation of tractor trolley axle by using finite element analysis approach "Studied on Evaluation of Tractor Trolley Axle by Using Finite Element Analysis to modify existing rear axle of 6.0-ton tractor trolley. Fatigue failure of the rear axle finite element model was predicted after the dynamic load was imposed on it. Spectrum analysis revealed that the failed axle shaft material is SAE 1020 steel. Fractographic features indicated that fatigue was the main cause of failure of the axle shaft. It was observed that the fatigue cracks originated from transition areas due to sharp corners. Modified axle produced with casting process with the use of ductile iron (65- 45-12 or 450-12) strengthened.

Javad Tarighi et al.[3] "Static and dynamic analysis of front axle housing of tractor using finite element methods" Studied on MT250D Mitsubishi Tractor with 25hp power is used to do light agricultural operations. Finite element analysis results showed that the maximum stress of 238.84MPa is applied on the upper housing. According to Von Misses theory, the value of maximum applied stress and allowable stress, the safety factor of 1.05 was obtained which is less than the required value. The first four natural frequencies of housing were found as 678.54, 720.29, 908.78 and 1877 Hz, respectively. The obtained factor of safety is very low. The present study clearly indicates that the front axle housing of MT250D Mitsubishi tractor is not strong enough to be mounted on a tractor

Min Jhang, Lijun Li (2015) [4] analyzed stress and fatigue life of front axle beam by finite element analysis and experimental method. Also, investigate the effect of crack parameters like length and depth on fatigue life.

Topac (2008) [5] evaluated the fatigue failure prediction and fatigue life of a rear axle housing prototype by using Finite element analysis of heavy duty truck. The expected load cycles required to fail during the vertical fatigue tests of a rear axle housing prototype is studied and mechanical properties were determined of housing material.

Manish S Lande et al. [6] "comparative analysis of tractor's trolley axle by using FEA. (by considering change in materials existing shape and size)" Evaluate that the existing rear axle shaft used in tractor trolley shows that the existing axle has greater factor of safety so un-wontedly heavy axle is used for trolley in existing condition which increase the weight of axle as well as cost of axle. But the newly designed axle with different cross section and different material show that we can maximally reduces the 33.92% weight as compare to the existing axle. Also reduces the cost of trolley axle as the weight of the axle reduces. We reduce the cost of axle and the deformations as well as stresses developed in new designed axle are in within limits the minimum cost obtained for I cross section axle of SAE 1040 material, the deformation for that axle is 0.984 mm and stresses developed in that axle is 259.525 (N/mm2) which are in within limit.

A.K. Acharya et al. [7] "Failure analysis of rear axle of a tractor with loaded trolley" This paper describes the failure analysis of the rear axle at the root of the spline of a tractor with a loaded trolley used for haulage.The front wheel lifting and the failure of the rear axle at the root of the spline though mainly due to the transfer of weight, not sufficient attention. By reducing the hitching height and it was observed that by reducing the hitching height to 16.00 inches (which is normally taken as 19 to 20 inches) with reduction in the weight transfer factor by nearly 20%.

G.K. Nanaware et al.[8] "Failures of rear axle shafts of 575 DI tractors "Studied on Rear axle shafts of 575 DI tractors manufactured by Mahindra and Mahindra Ltd. Tractor failed before completion of warranty period. Most of the shaft failures (nearly 80–85%) occur during puddeling operations. Rear axle shafts fail in the spline portion. Cracks were found at the root of the splines. The causes of failure and remedies have been discussed in this paper. The failure of rear axle shafts is due to inadequate spline root radius, which led to crack initiation and subsequent crack growth is by fatigue under the cyclic loading conditions of field operation. The present study clearly indicates that the optimum value of the spline root radius i.e. 1.5 mm (by FEA) should be used together with shot peening of the spline region and addition of boron to the material to increase fatigue strength.

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Javad Tarighi et al.[10] "Static and dynamic analysis of front axle housing of tractor using finite element methods" Studied on MT250D Mitsubishi Tractor with 25hp power is used to do light agricultural operations. Finite element analysis results showed that the maximum stress of 238.84MPa is applied on the upper housing. According to Von- Misses theory, the value of maximum applied stress and allowable stress, the safety factor of 1.05 was obtained which is less than the required value. The first four natural frequencies of housing were found as 678.54, 720.29, 908.78 and 1877 Hz, respectively. The obtained factor of safety is very low. The present study clearly indicates that the front axle housing of MT250D Mitsubishi tractor is not strong enough to be mounted on a tractor. Suggested modifications to increase strength and reliability are as follow: 1. Increase the thickness of upper box 2. Design a lightweight mechanical shovel with low Capacity of bucket 3. Increasing the shell thickness in areas where stress Concentration occurs

Siddarth dey et al. [11] "Structural Analysis of Front axle beam of a Light Commercial Vehicle (LCV)"Studied on front axle design by the noise and vibration analysis at static and dynamic loading conditions. The model selected is that of a light commercial vehicle (LCV) which has a gross vehicle load of around 5-10 tons. Stressed regions due to vehicle static load, braking torque, and during turning is established and the front axle beam is investigated to find out its factor of safety and maximum deformation under the mentioned conditions. The results of the transient analysis showed that the maximum Von-Mises stress in the optimized front axle was 351 MPa. The value of maximum bending stress due to transient loading conditions was lower than the yield stress strength. Because the transient dynamic loads were applied on the axle suddenly, a permanent deformation could not take place. Therefore, it is concluded that the optimized front axle of combine has enough strength under transient loading conditions. The designed front axle is strong enough to be installed on the LCV and the optimized front axle has enough strength under static, harmonic and transient loading conditions.

M.M. Topaç et al. [12] "Fatigue failure prediction of a rear axle housing prototype by using finite element analysis." Premature fatigue failure of a truck rear axle housing prototype was investigated by using finite element analysis. In the analyses, stress concentrated regions were predicted at the banjo transition area. The regions in which the fatigue cracks originated were well-matched with the results of the analyses. Critical regions determined are subjected to a combined steady and cyclic tensile stress. Analyses showed that premature fatigue failure can occur prior to the predicted 5×105 minimum cycles limit, if this load is applied in a cyclic manner. Give solution of the problem, Redesigning of the banjo transition area and increasing the thickness of the reinforcement ring may be a good alternative to obtain a longer fatigue life, which can satisfy minimum design criteria.

G.Rajesh Babu and N.Amar Nageswara Rao et al.[13] "Static and modal analysis of rear axle housing of a truck" carried out the static and dynamic analysis of banjo type rear axle housing by using FE method for two different materials like cast iron and mild steel. The induced deformation in cast iron housing is greater than mild steel housing and also the natural frequencies of the cast iron are lower than the mild steel. Also observed that the stress induced in the cast iron is lower than the mild steel and concluded that the cast iron is preferred for production of rear axle housing.

Osman Asi et al.[14] "Fatigue failure of a rear axle shaft of an automobile" This paper describes the failure analysis of a rear axle shaft used in an automobile which had been involved in an accident. The failure zones were examined with the help of a scanning electron microscope equipped with EDX facility. Spectrum analysis and micro-hardness measurement show that the failed axle shaft material was AISI 4140 steel as hardened and tempered condition. Fractographic features indicated that fatigue was the main cause of failure of the axle shaft. It was observed that the fatigue cracks originated from welded areas. Due to the improper welding. So improper welding of hardened materials involves low ductility in the HAZ, stress concentration points, and inclusions in the structure that served as responsible for the fatigue cracks. So that preheat treatment prior to welding and post heat treatment after welding of medium-carbon steels are necessary to control the hardness level in the HAZ and minimize residual stress.

Guruprasad.B.SI et al. [15] "Evaluating FOS for rear axle Housing using hybrid aluminium Composites." It is observed experimentally that the reinforced aluminum with Fly ash and Al2O3 enhances mechanical properties in comparison with monolithic metal. In present work with the use of finite element analysis factor of safety for rear axle housing is estimated for both hybrid composite and monolithic metal. The fatigue factor of safety for composites is greater than the unreinforced alloy under dynamic loading conditions. The few results show that composite material have more safety factor for maximum loading when the load is applied statically.

Meng Qinghua et. al [16] "Fatigue failure fault prediction of truck rear axle housing excited by random road roughness "Show that a premature fatigue failure that occurred prior to the expected load cycles during the vertical fatigue tests of a truck rear axle housing prototype. Analyzed for fatigue failure of truck rear axle housing excited by random load distribution from the uneven road profile. During operation of the truck the random load acts on the axle housing in vertical direction causes severe impact on the fatigue life of the components. By using random load distribution data the fatigue life of the truck is analyzed and also design optimization is proposed to increase the fatigue life of the components according to the simulation results and location of failure.

Mehmet Firat et. Al [17] "A computer simulation of four-point bending fatigue of a rear axle assembly" evaluated that the bending fatigue test of a rear axle assembly is simulated by using a FE-integrated fatigue analysis methodology. The fatigue test cycles and crack initiation locations are predicted using Smith-Watson-Topper and Fatemi-Socie fatigue damage parameters. Both damage parameters provided conservative test cycle estimates for the test conditions simulated. It is also observed that von Mises stress distributions cannot be used to predict fatigue crack initiation locations while Smith–Watson–Topper critical plane parameter estimated the cracking location suitably. Comparisons with the prototype tests showed the applicability of the proposed approach. It was also determined that von Mises stress distributions may not be an accurate measure for fatigue failure locations of rear axle in bending fatigue tests. The need of modelling the manufacturing effects in fatigue life analysis was also pointed out.

III. Conclusion

Various researches are conducted to analyze fatigue failure locations of rear axle, stress generation and deformation. The viability of composite material for front axle is also studied by various scholars. The findings have shown that magnitude of load applied, axle geometry, kingpin type and material are major factors which determine the axle life. The study also discusses about different inspection methods for early detection of failures and methods to improve quality and life.

References

[1] Zuo, L. and Nayfeh S.A. 'Minimax Optimization of Multidegree-of-freedom Tuned Mass Dampers' Journal of Sound and Vibration, Vol. 272, 893-908, 2004
[2] Sanjay Aloni and Sandip Khedkar "Comparative evaluation of tractor trolley axle by using Finite Element analysis approach", International Journal of Engineering Science and Technology.vol-4,ISSN:0975-5462,April-2012.
[3] Javad Tarighi, Seyed Saeid Mohtasebi, Reza Alimardani, "Static and dynamic analysis of front axle housing of tractor using finite element methods", AJAE 2(2), 45-49, 2011.
[4] Min Zhang, Xiangfei Ji, Lijun Li, A research on fatigue life of front axle beam for heavyduty truck, Advances in Engineering Software 91 (2016) 63–68
[5] M.M. Topac , H. Gunal , N.S. Kuralay, Fatigue failure prediction of a rear axle housing prototype by using finite element analysis , Engineering Failure Analysis 16 (2009) 1474–1482
[6] Leon, Reducing the Weight of a Frontal Truck Axle Beam Using Experimental Test Procedures to Fine Tune FEA, MSC Automotive Conference., 2010.
[7] Manish S Lande and Sunil J Rajpal, "Comparative analysis of tractor's trolley axle by using FEA. (By Considering change in materials existing shape and size)",International Journal of Mechanical Engineering and Robotics Research ISSN 2278 – 0149 Vol. 2, No. 3, July 2013.
[8] A.K.Acharya, I. Panigrahi, P. C. Mishra, "Failure analysis of rear axle of a tractor with loaded trolley", international journal of innovative research & development Vol 2 Issue 10ISSN;2278-0211 oct-2013.
[9] G K Nanaware, M J Pable, "Failures of rear axle shafts of 575 DI tractors", Engineering failure analysis 10 (2003) 719-724, ELSEVIER.
[10] Sanjay Aloni and Sandip Khedkar "Comparative evaluation of tractor trolley axle by using Finite Element analysis approach", International Journal of Engineering Science and Technology.vol-4,ISSN:0975-5462,April-2012.
[11] Javad Tarighi, Seyed Saeid Mohtasebi, Reza Alimardani, "Static and dynamic analysis of front axle housing of tractor using finite element methods", AJAE 2(2), 45-49, 2011.
[12] Siddarth DeySri Rama Chandra Murthy. D, P.Baskar, "Structural Analysis of Front axle beam of a Light Commercial Vehicle (LCV)'', International Journal of Engineering Trends and Technology (IJETT)-Volume 11 Number 5 -pp 2231-5381 May 2014.
[13] M M Topac, H Gunal, N S Kuralay, "Fatigue failure prediction of a rear axle housing prototype by using finite element analysis", Engineering failure analysis 16 (2009) 1474-1482, ELSEVIER.
[14] G Rajesh Babu, N Amar Nageswara Rao, "Static and modal analysis of rear axle housing of a truck", International Journal of Mathematical sciences, Technology and Humanities 7 (2011) 69 -76.

[15] Osman Asi, "Fatigue failure of a rear axle shaft of an automobile", Engineering Failure Analysis 13 (2006) ,pp 1293– 1302.
[16] Guruprasad.B.SArun.L.R, Mohan.K," Evaluating, "fos for rear axle Housing using hybrid aluminium Composites", International Journal of Innovative Research in Science, Engineering and Technology Vol. 2, Issue 6, ISSN: 2319-8753 June 2013.
[17] Meng Qinghua, Zheng Huifeng, LV Fengjun, "Fatigue failure fault prediction of truck rear axle housing excited by random road roughness", International Journal of the Physical sciences Vol. 6(7), pp 1563-1568, 2011.
[18] Mehmet Firat."A computer simulation of four-point bending fatigue of a rear", axle assembly", Engineering Failure Analysis 18, 2137–2148(2011).

