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Modification and Analysis of Locomotive Brake Hanger

A. Purushoatham
Department of Mechanical Engineering,
Sree Nidhi Institute of Science and Technology,
Ghatkesar, Hyderabad, A.P., India-501 301
Email:apurushotham@rediffmail.com

***Abstract* – A locomotive or engine is a railway vehicle that provides the motive power for a train. The locomotives are manufactured, inspected by the Railway Company to ensure safe operation. All the components must be designed and maintained to perform their intended function, in order to ensure the safety of the passengers. There are some systems which need inspection. One such system is the BRAKE SYSTEM. The speed of the locomotive is dependent on the effectiveness of the Braking System used. With the effectiveness of the Braking system, in must be ensured that, the safety of the passengers is also provided, that is the mechanical vibrations and jerks are to be minimized. One of the components in the Brake system more subjected to failure is the BRAKE HANGER. In this paper, the Failure of the Brake hanger is analyzed in Static and Dynamic stress conditions. The approach adopted is based on the previous failure data of various components that are observed in various loco sheds of Indian Railways. After evaluating the reliability of different systems, the system with the least reliability is considered for the failure analysis. One such system having least reliability is the BRAKING SYSTEM. With the past history, the low reliability for the braking system is due to the frequent failure of the BRAKE HANGER, under STATIC and DYNAMIC loading. By performing the Structural Analysis on that component, various reasons for the failure are found out. If the component is prone to cyclic loads then the Dynamic analysis is performed and the frequencies are calculated. Finally, necessary modifications in the design of the Brake Hanger are made. From the Structural analysis, the parts of the component where the stress distribution is more are obtained. Then the necessary changes are made in the component design, to reduce the stress concentration. For the cyclic loads, the Dynamic analysis is performed and from the results, the time period is calculated within which the component functions with a high reliability. Thus the overall safety of the component is ensured.**

***Keywords* – Locomotive, Hanger, Von Mises Stresses, Fatigue Failure.**

I. Introduction

A locomotive is a railway vehicle that provides the motive power for a train. A locomotive has no payload capacity of its own, and its sole purpose is to move the train along the tracks. Regardless of the remarkable increase in the train speed, trains need to be stopped safely within a limited braking distance without causing any discomfort to the passengers. This discomfort may be due to the vibrations and shocks occurred due to the sudden application of brakes. This describes that the speed of the locomotive is dependent on the effectiveness of the braking system. Thus, every component should be functioning properly in order to yield an effective and efficient braking system. On considering the components of the braking system, one of the important components that definitely needs to be taken into consideration is the brake hanger. As this plays a major role in the proper working of the braking system. Both the inner as well as outer hangers are breaking. However, the cases of breakage of inner hangers towards bogie frame are much more, which account to over 80% of the total failures.

During the brake application, the brake beams on either side of a wheel set are moved by the brake cylinder through the brake rigging so that the brake block holders are pulled towards the wheel treads. The brake beams, however, only control the movement of the brake blocks in the horizontal plane and provide no vertical restraint. The brake block holders are prevented from dropping to the ground by brake hangers, to which they are connected by the lower brake hanger pins. The upper part of the brake hangers are connected to brackets on the bogie frame by the upper brake hanger pins. The brake head pins and the upper and lower brake hanger pins are all secured using washers and a split pin. The brake beam however only controls the movement of brake blocks in horizontal plane and provides no vertical restraint. The upper part of the brake hangers are connected brackets on bogie frame by the upper brake hanger-pins.

The typical brake hanger assembly in a locomotive:

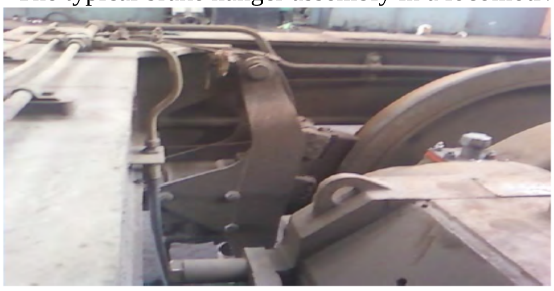

Fig.1.1. Brake Hanger

Breakage of Brake Riggings: The breakages of hanger are directly related with the higher speeds, which are due to high level of vibrations and shocks at higher speeds. The matter was so serious from the point of view of safe train operation. Of late, Railways have reported the failures of brake hangers in locos only from 2004.100% of the breakage took place at the top of the hanger plate and just below the welding done for fixing of additional ring to enable fixation of bush of 20 mm width. Both the inner as well as outer hangers are breaking. However, the cases of breakage of inner hangers towards bogie frame are much more which

80% of the total failures. The outer brake hanger has been rubbing with the bogie frames in locomotives. The rubbing marks are varying from 0 to 4 mm depth in the 12 mm thick plate of brake hanger. Almost in 90% of the locomotives the brake hangers are rubbing with the bogie frame

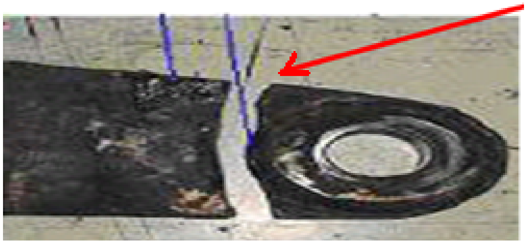

Fig.1.2. Breakage of Hanger

The main objective of this paper is to study the failure causes in static and dynamic conditions and obtaining modified solution to the brake hanger. The rest of the paper is organized in the following manner: Section two covers brief literature on Brake Hanger. Modifications suggested after the analysis is given in section 3. Section 4 draws conclusions.

II. Review of Literature

The description of Locomotive brake hanger is described in [4]. The authors [1,4} described the failure of brake hanger under different dynamic conditions of train movement. The pattern of failure and action plan to avoid failure of brake hanger are discussed in [2]. The measurement friction created in the brake surface and wheel and its role in the failure of Hanger is discussed in [3].No other is reported regarding the modification of brake hanger manufacturing to avoid the failure at neck zone. The dynamic analysis is also be an important analysis to study the failure of hanger. These issues are studied in this paper with the simulation tool ANSYS.

III. Simulation Studies and Modifications

The brae hanger is modeled in Ansys software and is shown In Fig 3.1. The elements model with loading is shown in Fig 3.2.

Fig.3.1. Model of Brake Hanger

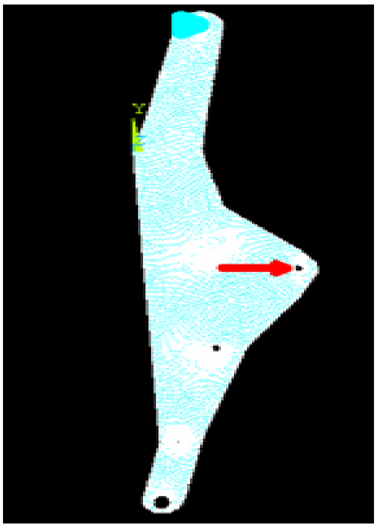

Fig.3.2. Element Model of Hanger

The resultant displacement and vonmises stresses are obtained as shown in contour figures Fig. 3.3 and 3.4.

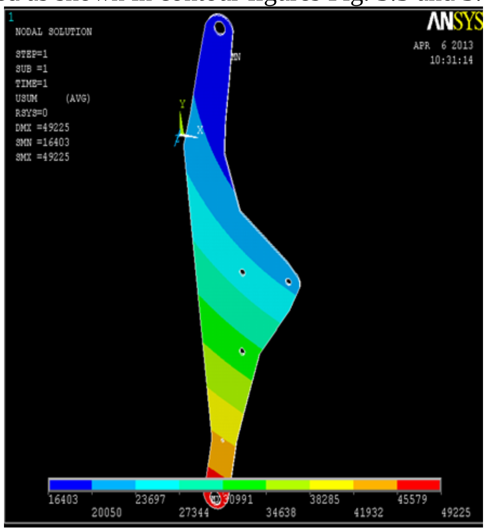

Fig.3.3. Displacement Contour plot

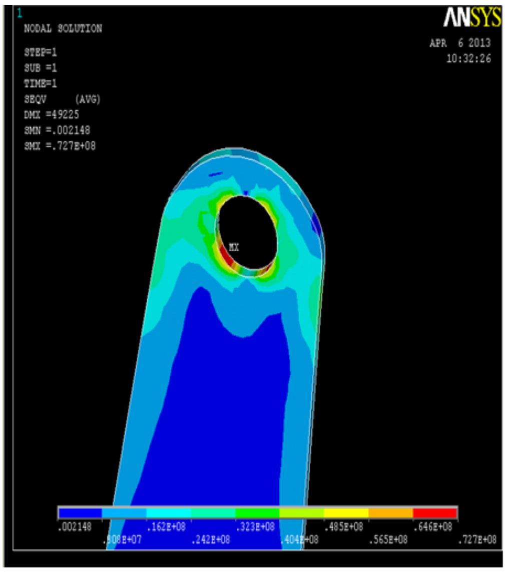

Fig.3.4. Stress Contour plot

The static analysis is the study of various forces acting on the body, in static equilibrium, which is done so far However, for the complete analysis of a component it is necessary that the functioning is studied in dynamic condition.It gives a complete picture of the failure conditions when it is subjected to fatigue. Dynamic analysis is carried out in two stages in this project namely: Modal analysis and Harmonic analysis. Modal analysis deals with the calculation of natural frequency of a component. Harmonic analysis calculates the peak value of the amplitude at the corresponding frequency that is obtained in the modal analysis. This analysis plots its curves based on the modal analysis charts.

The modal analysis gives first four fundamental frequencies as: 0.005, 25.537, 318.32, 886.49 and 1487rad/sec. The mode shapes at frequencies 886.49 and 1487.5 rad/s are given in Fig.3.5 and 3.6.

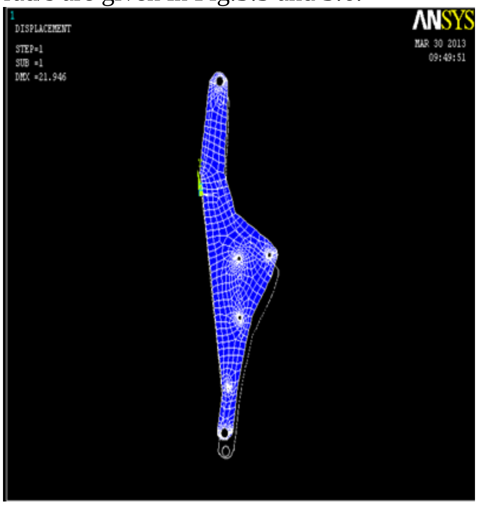

Fig.3.4. Mode shape at w=886.49Rad/s

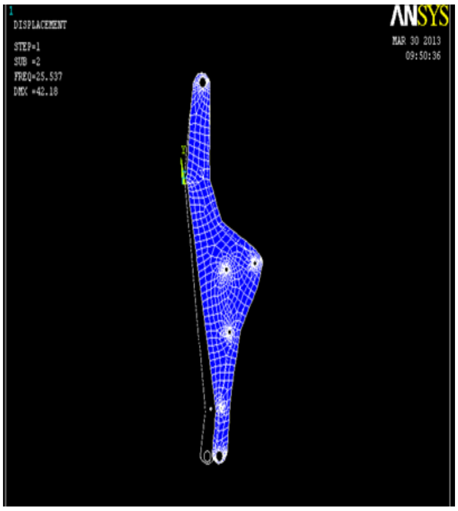

Fig.3.5. Mode shape at w=1487.5 Rad/s

The Harmonic Analysis is carried out with an excitation force whose frequencies changed from very low to maximum of 200 Rad/Sec. The meshed Model for harmonic analysis is shown in Fig.3.6.The response of displacement under frequency force is shown in Fig.3.7.

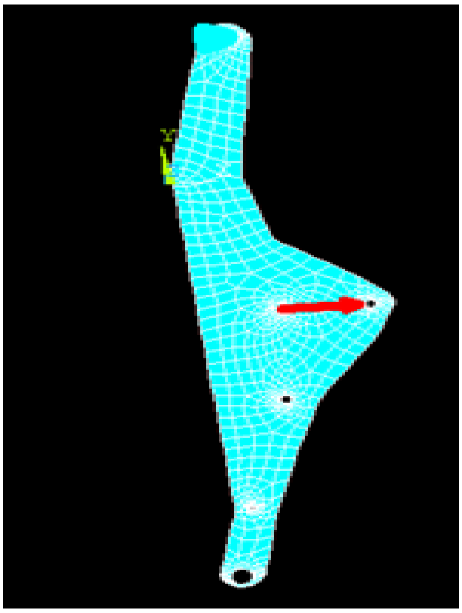

Fig.3.6. Model for SHM

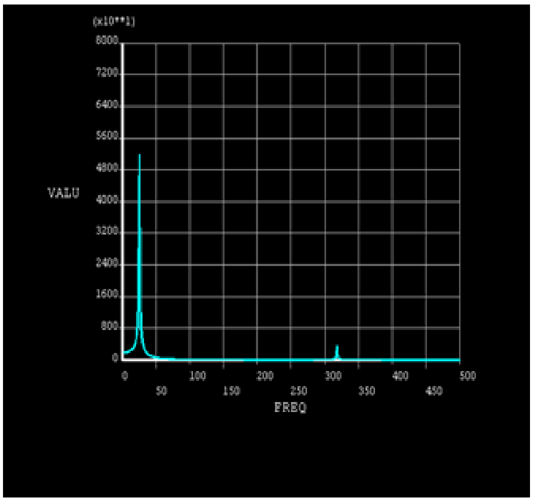

Fig.3.7. The displacement amplitude in frequency range(0~500R/s)

When frequency of exciting force varied from 500 to 1000 rad/s, the response obtained is shown in Fig.3.8.

Improvements and Modifications:

The main causes for failure can be enlisted as☹

i) Formation of **crack** at the region of welding of the bush near the hole and (ii) Development of the **crack** into progressive breakage. Reason for the formation of crack is During micro and macro structural examination, it is found that there is a formation of bainite in the alloy steel which is more brittle in the heat affected zone. The breakage of lever arm is attributed to presence of bainite and martensite at heat affected area due to improper welding execution. It is observed that the breakage have been taking place from the heat affected zone due to excessive heat generated during the process of welding. This is caused because of the excessive heat generation, may be due to: Wrong selection of electrodes, High current and Non-standard procedure of welding techniques for welding structural steel as per IS:8500. Eliminating the implementation of welding technique and suggesting the total hanger with a single piece casting component , the analysis shows the stress contours as in Fig3.10. The maximum value of the stress value reduced to 64.6 Mpa from 200 Mpa.

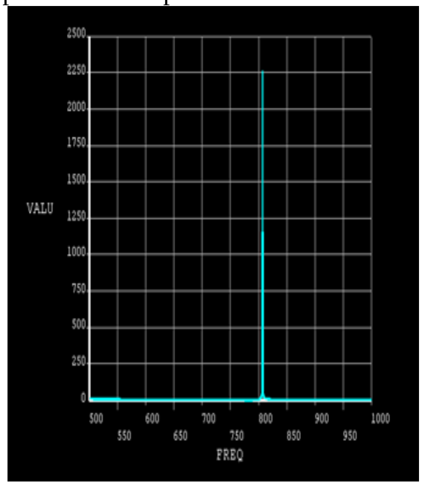

Fig.3.8. The displacement amplitude in w(0~500R/s)

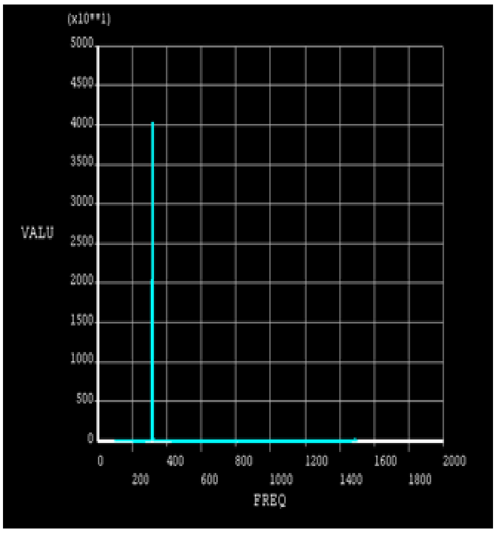

Fig.3.9. The displacement amplitude in w(0~500R/s)

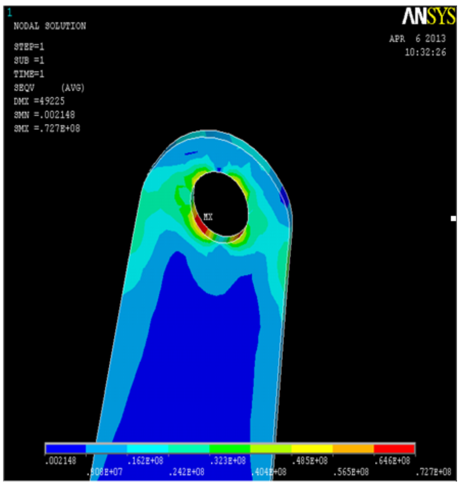

Fig.3.10. Stress contour without welding.

IV. Conclusions

The necessity to study the failure of the BRAKE HANGER is identified in Railway Locomotives. The stress analysis is performed using ANSYS software to identify the stress concentration locations on the brake hanger. As the brake hanger is subjected to cyclic loading, dynamic analyses are also performed. The various regions on the brake hanger where the stress concentration is more are identified in dynamic and static conditions. This enables us to trace out the parts which are needed to be improved. Then the necessary modifications are suggested such as, Manufacturing the component by Casting; proper Welding techniques to be adopted in order to eliminate the Heat Affected Zone; Heat Treatment (Annealing) of the brake hanger in order to replace the formation of Martensite and Bainite with Pearlite.The final modifications are implemented on the brake hanger after considering the results and suggestions that are proposed in this project.

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Author's Profile

A. Purushotham

presently working as a Professor in the Department of Mechanical Engineering, SreeNidhi Institute of Science and Technology Hyderabad, A.P. India. To his credit, there are forty four publications in various journals and conferences. He is also actively working on aicte funded projects. His research interests include Design, Robotics, Composites and experimental stress analysis.