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INVESTIGATION AND MONITORING SYSTEM FOR RAILWAY DERAILMENT

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Abstract—**Since Railway is the second quickest and cheapest mode of transportation which make it largest mode of commutation over the world .In India alone it has 115,000 km of track length and It runs 12,617 trains to carry over 23 million passengers daily – equivalent to moving the entire population of Australia. India Railways runs more than 7,421 freight trains carrying 3 million tones (MT) of freight every day.**

Since cost of life and goods directly associated to Railway are too much it requires high level of security and safety associated to it. The objective of this research is to forestall all the passengers from any derailment mishap caused due to rail cracks or any other defects in rail tracks.

This research is based on the Nadal's theory and complex calculation of lateral and vertical vibrations for ride comfort. Based on the calculations, the frequency of vibrations may be analyzed and efforts can be taken to stop such type of accidents. As it is closely related to traveler and freight transportation, it owns high risk in terms of human lives and value of assets which is our prime focus. Railway has adapted new technologies and higher safety standards but in spite of all these efforts, we are unable to control accidents and risk associated to derailments and collisions exists. However it may be reduced by elaborated analysis of the causes. Railway is also committed for high level of comfort for the passengers, hence several continuous efforts with complex and complicated actions and research are been made. Noise and vibration are known factors for discomfort, the most sources of vibration in an exceedingly train are track defects, that causes during wheel rim climb or rail change due to track defects. This is the reason why it has been the topic of intense interest for several trains manufacturers and researches over the globe. Although new techniques in producing and style guarantees higher ride comfort but fully elimination of track defects due to numerous ground irregularities is still not possible.

Index Terms— **Vibration Monitoring, Dynamic Control, Measuring Motion, Acceleration, Inclination, Graphical User Interface.**

I. INTRODUCTION

Oscillation Monitoring system(OMS) is the device which is equipped at the location on the floor of a railway vehicle and simultaneous measurement of distance from fixed points of track on real time basis to measures vertical and lateral accelerations. Oscillation Monitoring System (OMS) is a laptop based equipment for track monitoring and thus to ensure the safety of the railway tracks. It is capable of recording speed, vertical and lateral acceleration on the loco/coach floor, ride index, different events and also the distance/time at which each events and acceleration occurred. It can give instantaneous speed (if system runs in techno mode). Sufficient memory capacity with latest hard disk has been provided to store the collected data. Accelerometer unit is operated through battery and the battery can be charged through battery charger. Also the system will work on external power supply. Same way laptop also can be operated through battery and battery can be charged using standard adapter available with laptop [1, 2].The Tachometer linked/attached to the coach gives the actual distance travelled and on-line recording is done during the testing. The equipment is provided with a GUI based event marker for the operator to enter the events, during the testing.

Vibration Sensing is referred as physical and mechanical phenomenon of oscillation of an object about some equilibrium point. Vibration monitoring technique has gained wide interest and acceptance for Oscillation Monitoring applications. This is based on exciting vibrations in component by local external impact or recording the vibration generated in a component under operating conditions the most common source of vibration are misalignment, tilting train etc.

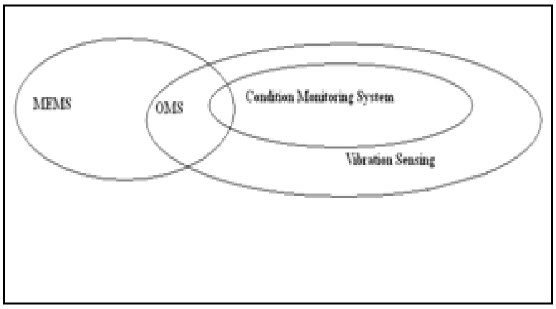


Fig 1: Relationship of OMS to related fields

Micro Electro- Mechanical Systems (MEMS) is a technology used to create tiny integrated systems or device that combine mechanical and electrical components. These are manufactured using integrated circuit (IC) batch processing techniques The dimension or size of a MEMS can be from several millimeters to less than one micrometer, a dimension many times smaller than the width of a human hair. Some types of MEMS doesn't have any mechanical part but still classified as MEMS because they have miniaturize structures used in conventional machinery, such as springs, channels, cavities, holes and membranes. The main functional elements of MEMS are Miniaturized structures Sensors, Actuators, Microelectronics. But the most interesting elements are the microsensors and microactuators. Microsensors and microactuators are also known as "transducers", It convert energy from one form to another. Here microsensors, the device converts a mechanical signal into an electrical signal.

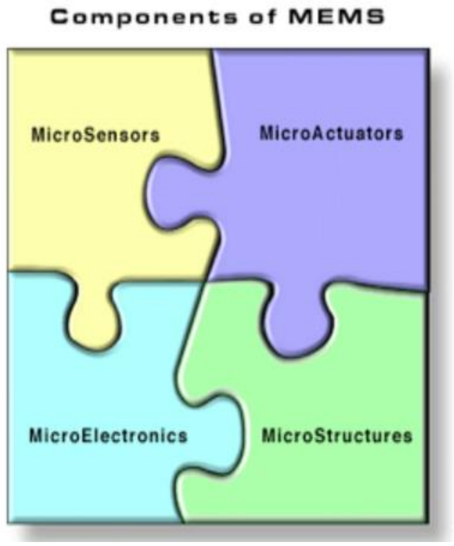


Fig1. Components of MEMS

A typical MEMS structure contains moving masses, springs, and dampeners, which work in the similar way as the mass-spring model. MEMS accelerometer is commonly used in today's electronic home appliances, such as vibration detectors in a washing machine or dryer so that users can avoid unbalanced load and avoid excessive wear. arts, before a failure occurs. One and two axis accelerometers are mainly used in the automotive market for passive safety systems, like frontal and lateral air-bags. Accelerometers and gyroscopes are also used in navigation systems and active safety systems, like Vehicle Dynamic Control [4,5]. MEMS experts are now focusing their efforts on the improvement of 'smart sensors'. These are MEMS devices with integrated processing capability, which are capable of running sensor-related algorithms independently from the main processor unit, reduce the consumption of power at the system level,

Condition Monitoring This is the process or strategy of predictive maintenance followed to monitor actual assets condition and problem areas. Based on this decision of maintenance action are usually taken. Condition monitoring includes measurement of various parameters related to the mechanical condition of the machinery, such as: Performance, Vibration, Bearing temperature, Oil debris, Oil pressure. If this machine is properly analyzed then it becomes a valuable tool to determine when the machine needs maintenance and in the prevention of machinery failure which can be catastrophic and result in unscheduled break downs [6].Unlike MEMS and Condition monitoring System, the main goal of OMS is track monitoring and thus to ensure the safety of the railway tracks. The study employed theoretical modelling and experiments. The results showed that the derailment quotient or the ratio of the lateral to the vertical force (L/V ratio) at the wheel rail interface alone was not sufficient to predict the safety against derailment. Hague et al. (1996) reported a nonlinear wheel set model for derailment prediction. The modelling provided special emphasis on safety related behavior of the wheel set negotiating both the tangent and curved tracks. The wheel set models accounted for non- linearity's due to wheel rail profile geometry and creep force and the longitudinal translation of the contact patch as a function of wheel set yaw angle. The authors exhibited that the model was capable of predicting the wheel set dynamic behavior during wheel climb, wheel lift, steering characteristics during curve negotiation and also limit cycle behavior on the tangent track. Nagase et al. (2002) reported experimental results of the wheel climb derailment. The risk of the derailment was evaluated using Nadal formula (ratio of the lateral force to the vertical force applied to the wheel) as well as by measuring the wheel vertical displacement using a high precision laser displacement sensor. As a result, it was found that the adhesion coefficient had a major influence on the occurrence of wheel climb derailment. The conditions necessary to sustain equilibrium of the forces in flange contact were considered in 1908 by Nadal in a classical analysis144 which provided a derailment criterion. Gilchrist and Brickle145 applied Kalker's theory of creep in a re- examination of Nadal's analysis and they have shown that Nadal's formula is correct for the most pessimistic case when the angle of attack is large and the longitudinal creep on the flange is small[7].

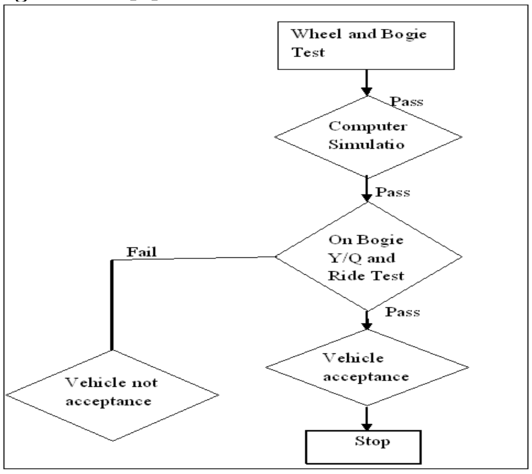


Fig2: Work Flow diagram

II. RELATED WORKS

Wherever Time On thinking of the motion of railway cars, a vehicle body , for example has six degrees of freedom ; parallel motions in the lateral, vertical and longitudinal directions, and turning motions of yawing(around vertical axis), pitching(around lateral axis) and rolling (around longitudinal axis). Among them, the longitudinal motion is related to the force through couplers and to acceleration or deceleration of vehicles in running. Vertical and pitching motions in running of vehicle are mainly excited by vertical variation of track (called irregularity of longitudinal level). Lateral, yawing and rolling motions are produced with relation to lateral variation (irregularity of alignment), level variation between right and left rail (irregularity of cross level) and spacing between the two rails (irregularity of gauge). On longitudinal motion, a vehicle motion in a train hauled by a locomotive, shock at the hitting with vehicle to vehicle at yard (place to assort freight train), and on vertical pitching motions, riding comfort (feeling of passengers against vibration), are main problematic points. On the motion of vehicle related with derailment, the difference of wheel loads of right wheel and left one and the side thrust of a wheel are the main factors [8].

Creep coefficient between wheel and rail: When an advancing wheel set is pushed in lateral by a constant force, it is experimentally and theoretically observed that the wheel set moves laterally with a speed related to the strength of the applied force and the advancing speed of the wheel set. In small range of displacement, this lateral speed of the wheel set is assumed to be proportional to the force strength and the advancing speed of the wheel set, and the following formula holds.

$$F=f*(Yw/v)$$

Where F stands for force applied in lateral and f is a proportional constant, Yw is the lateral displacement of a wheel set and v is the forward speed of a wheelset, f is called creep coefficient of a wheelset to rails and its unit is same as that of force[9] Railway track maintenance is constantly carried out, and so called track irregularity has been kept under certain limits. It is said that the relation between wavelength and amplitude of track irregularity is almost in proportion. Considering a certain frequency, such as natural frequency of train, the amplitude of forced vibration by track irregularity increases as speed up of the railway train. Railway vehicles giving a range of more comfortable facilities as compared to the other modes of transportation in respect to the ability of performing sedentary activities like reading, writing, eating, etc. Generally, the facilities seen in the railway passenger cabin are tables, huge seats, special boxes, as a result, most travellers choose railways to be able to work during the journey. However, the issue of comfort in respect to vibration has become a common question to the railway industry since vibration plays a major role for the travelling comfort and ability to perform sedentary activities. Railway companies throughout the world are looking for ways of increasing train speeds and ride comfort. Because most countries have a significant mileage of curved track, measures must be taken to compensate for the lateral accelerations on curves if speed is to be increased without detracting from comfort [10]. Ride quality is interpreted as the capability of the rail road suspension to maintain the motion within the range of human comfort and Sterling's ride index which is a measure of the ride index which is a measure of the ride quality and ride comfort used by Indian Railways. There have been various studies, which are contributed by many researchers respecting the dynamic analysis and to enhance the ride comfort while travelling. Kumar and Sujata [11, 12] presented the numerical simulation of the vertical dynamic behaviour of a railway vehicle and calculated Sperling’s ride index for comfort evaluation. They modelled a typical Indian rail road vehicle running on broad gauge for the analysis. Discusses the dynamic response of a typical pre-stressed concrete rail track sleeper due to wheel track interaction dynamics. Nielsen and Igeland [13, 14] are research the vertical moving behaviour for a railway bogie moving on a rail which is discretely supported by sleepers resting foundation. The effects of flaws on the moving surfaces of the wheel and rail were studied by specifying irregularity functions on these surfaces. Bureika and Subacius [15] investigated the dynamics of vertical interaction between a moving rigid wheel and a flexible railway track. Ganga dharan et al studied the influence of different track irregularities on dynamic response and coupling between vertical and lateral dynamics.

III. PROPOSED APPROACH

A graphical user interface (GUI) is a pictorial interface between user and a program. A GUI can use to make programs easier to providing them with a consistent appearance and with intuitive controls like push buttons, list boxes, sliders, menus, and so forth. The GUI should behave in an understandable and predictable manner, so that a user knows what to expect when he or she performs an action. For example, when a mouse click occurs on a push button, the GUI should initiate the action described on the label of the button. MATLAB GUIs are using a guide for creating tools, the GUI Development Environment. This tool allows a user to layout the GUI, selecting and aligning the GUI components to be placed in it. Once the components are in place, the user can edit their properties: name, color, size, font, text to display, and so on. When guide saves the GUI, It creates programs with skeletal function that the programmer can modify to implement the GUI operations behavior. When the guide is executed, it creates a layout editor. Large white area layout area with grid lines, where a programmer can layout GUI. In the layout editor window, there is a palate of GUI components on the left side of the layout area. The user can create any number of GUI components by first clicking on the desired component and then dragging its layout in the layout area. At the top of the window is a toolbar with a series of useful tools that allows the user to distribute an aligned GUI components, modifies the properties of the GUI components, and adds the menu to the GUI, and so on..

IV. RESULT

1. On calculating the value of Y/Q, for both the forces we have the threshold values i.e. 1.4 and it should not exceed this value.
2. There is range of frequencies within a limit of 0.4 to 20 Hz. This has been taken as input to see the variations.
3. Applying the Sperling's Ride index formula for both the lateral and vertical directions to preserve the ride comfort of the passengers.
4. On plotting the graph for the vibrations, we could see the differences in safe and unsafe zone.

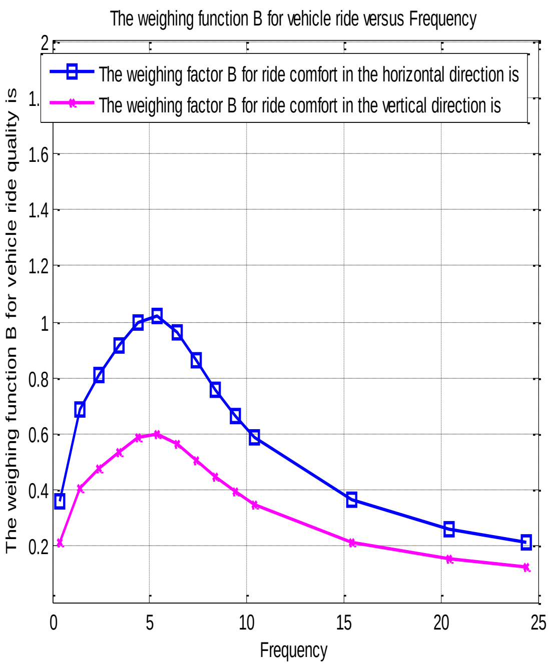
Result for Mathematical Analysis:

The simulation for both the graph shows some differences regarding the safe zone during derailment considering ride comfort and ride quality.

TABLE I. COMPARATIVES VALUES WITH RESPECT TO F, B, ACCELERATION AND Y/**Q**

	f	**B**	**Bw**	**Bs**	**Acceleration**	**Y/Q**
Standard Graph	**15Hz**	**3.2**	**1.0**	**0.6**	**10**	**1.4**
After Simulating the Input data	**15Hz**	**2.42**	**0.4**	**0.2**	**10**	**1.3**

Putting against these values we gave the graph as shown:



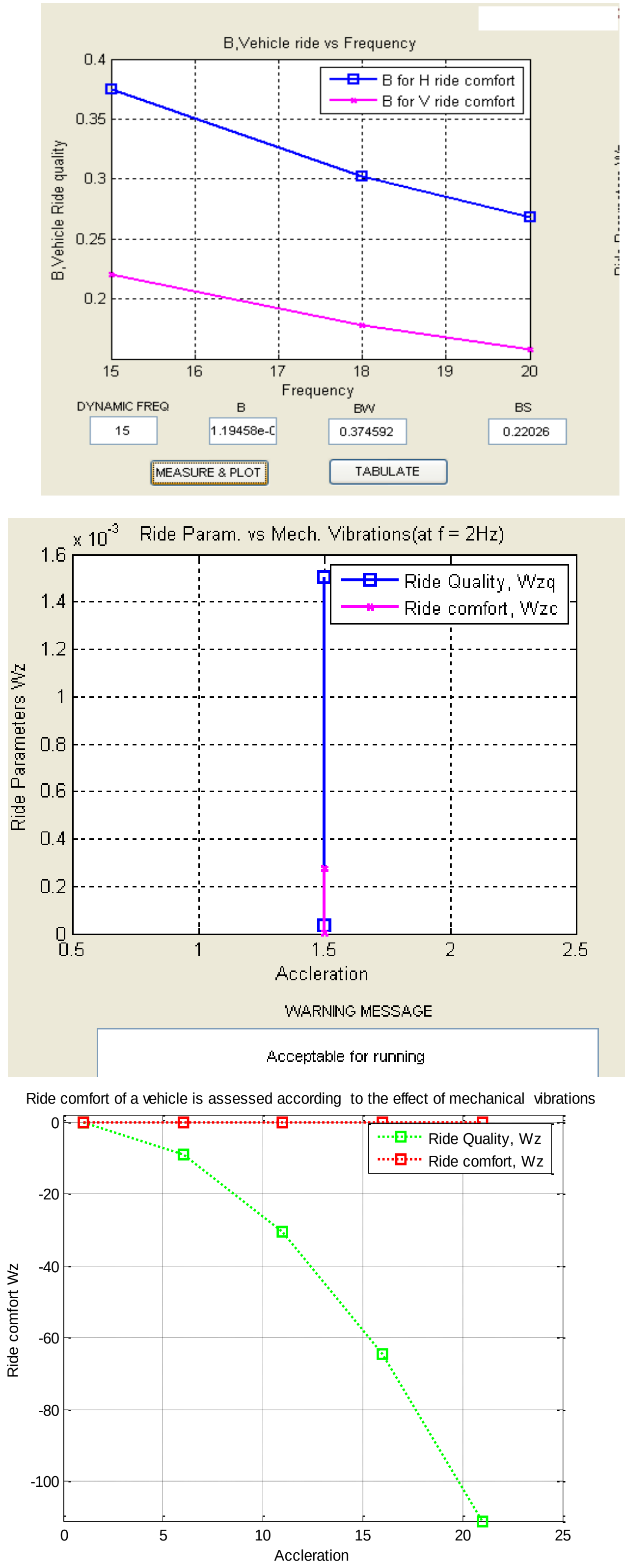


Fig 3. Comparison between the Standard values to the new Simulating values

TABLE II. Sperling's comfort level characterization.

Wz Ride Comfort		Wz Vehicle Ride	
1.0	Just Noticeable	1.0	Very Good
2.0	Clearly Noticeable	2.0	Good
2.5	More pronounced but not unpleasant	3.0	Satisfactory
3.0	Strong, irregular, but still tolerable	4.0	Acceptable for running
3.25	Very irregular	4.5	Not acceptable for running
3.5	Extremely irregular, unpleasant, annoying; prolonged exposure intolerable	5.0	Dangerous

V. CONCLUSION

To begin with in this study, an attempt to discuss several theoretical and practical forms of vibration sensing using OMS was made as an introduction to this field. The categorization analysis was made in order to give our personal view on how vibration of a track attacks categories, which are based on the lateral/vertical forces and the Ride comfort value which represents the comfort zone of the traveller.. An overview of the Nadal's theory and Sperling's ride comfort value was given as introduction to the method that was implemented as part of the project. We have made the attempt to project the differences that occur due to the frequency variations and this causes vibrations inside the train that are totally based on the changes of the forces due to the speed of the train and that only leads to the conclusion that the value of lateral and vertical forces is somehow directly proportional to the Ride index value which represents the comfort zone of the travellers. We performed for the condition of the track which shows the flow of vibrations in a graphical form based on the particular range of frequencies. There is a broad scope of improvement in both the theories that can be implemented for the safety of the passengers.

VI. FUTURE WORK

Railway Infrastructure is one of the fastest means of transportation, so it seeks safety and security for its passengers. Therefore, vibration sensing analysis is one of the major requirements and requirements for monitoring the condition of passengers. It is important to notice that when someone wants to travel through train, in our case, vibration sensing will most likely to be checked. The ability of detecting the vibrations through a sensor and using that real data as an input is the most important thing to monitor the accidents. Identify further work can address the subjective experiments and predictions of accidents using the above-mentioned subjective remedies. Another potential avenue is to combine different fundamental metrics for better performance prediction.

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