Comparative Review on Selection of Sensors For Track Crack Detection

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Abstract- *This paper comprises a comparative review of Railway track crack detection. The comparison is based on aspects such as operating efficiency, different methodologies of detecting crack. Following extensive research into various methodologies for detecting railway track cracks, it was discovered that the railway track inspection vehicle is an effective way to detect crack and avoiding human interference, it is found that robotic crack detection is best option. It not only gives accurate results but also saves a lot of efforts and time*

Keywords- Manual inspection, Vibration sensor, eddy current sensor, LED LDR sensors.

I. INTRODUCTION

Railways contain the largest organization worldwide. Railways are the lifelines of a country. Itis an important and essential mode of transportation in various countries. The railways have become a new means of transportation because of their capacity, speed, consistency, and reliability. Becauseit is closely related to passenger and goods transportation, they are also at high risk in terms of passenger lives and asset value. The poor maintenance of the railways can lead to major accidents and also harm surrounding properties when they are accidentally damaged. Even though accidents do occur, new technologies are used in daily life for the railway system, and safety measures are improved from time to time.

Thus, a proper planis required for the maintenance and inspection of tracks to detect cracks and other faults in the rail system. Detection and maintenance of rail defects are major problems for railway organizations all around the world. Weld problems, internal defects such as worn out rails, squats, head checks, palling and shelling, corrugations, and rolling contact fatigue (RCF)-initiated problems such as surface cracks are the most common. If these problems cannot be handled and corrected, they will lead to rail breaks and accidents. The railroad community and its maintenance personnel face a number of challenges, including performing effective. Inspections and making cost-effective maintenance decisions. If these problems are taken care of properly, inspection and maintenance decisions can decrease the potential risk of rail track breaks and derailments.

Methods of crack detection.

Manual visual inspection.

The method includes crack detection by human eyes, which means crack line monitoring is done by foremen on each and every line of the track.

Vibration sensor.

This method includes crack detection using vibration sensor, which means crack is detected using vibration sensors. The results are displayed in waveform using oscilloscope

Eddy current sensor.

This method includes crack detection using Eddy current sensor, which means crack is detected due to two opposing electromagnetic field generated by both (coil and the track surface).The results are displayed in waveform using oscilloscope.

LED LDR sensor.

This method includes crack detection using LED LDR sensors, which means crack is detected depending on amount of light falling on the LDR which is emitted by the LED.

Ultrasonic sensor.

This method includes crack detection using crack detected by ultrasonic sensor detected by sending out a sound wave.

II. CLASSIFICATION OF SENSORS

There are many methods for railway track crack detection, from manual visual inspection to robotic inspection and data transmission as advanced technology, but in general, the most commonly employed crack detection schemes are manual inspection, using sensing techniques such as vibration sensors, eddy current sensors and LED LDR sensors. There are various techniques that are employed, but which is the best method of crack detection in railways?

Let's plunge deep into the mentioned methods. The first one is the most obvious and most traditional way of crack detection in the railway network. I.e. manual inspection. A group of men go for manual inspection of railway track to see if there is any crack that has taken place on the track line. It requires a lot of hard work and takes too much time. Due to manual inspection, it is not possible to identify small cracks in the track and also, due to heavy sunlight, the gang men do not give proper attention due to exhaustion and boredom. This is a considerably very inexpensive method. Due to human interference, the crack generally go unnoticed due to improper maintenance and irregular human involvement in track line monitoring. Small unnoticed crack in the track can lead to derailment or hazardous accident in future so it is essential to avoid human interference in track line monitoring.

So further advancement was to avoid human interference and make use of robotic systems which use different types of sensors for crack detection. This brings us to the various methods of track crack detection .i.e. Vibration sensor - One of the technologies used to track equipment health is vibration monitoring. Vibration sensors can be used to give maintenance teams insight into conditions within key assets that might lead to equipment failure, allowing them to head off the need for major repairs. A vibration sensor is a device that measures the amount and frequency of vibration in a given system, machine, or piece of equipment. Those measurements can be used to detect imbalances or other issues in the asset and predict future breakdowns. When a piece of equipment starts showing signs of wear, vibration analysis can help with root cause analysis (RCA). By monitoring vibrations within the asset, you can track down the root source of the vibrations and subsequent damage. While vibration monitoring can help with RCA, it truly shines when used in predictive maintenance. When connected to a CMMS or oscilloscope, you're able to track vibration data in real time. When you see dangerously high levels of vibration reflected in the data, you'll know that you need to perform repair work on the connected asset. Vibration is made on the start point of the track. The vibration in the iron rails travels up to several kilometers. The sensed vibrations can be measured by a signal conditioning circuit and displayed on the oscilloscope but the system does not give an accurate result as expected due to damping of signals and also, vibrations can't be produced for long distances.

The other sensor that is used is the eddy current sensor. The eddy current sensor consists of a coil which has an AC supply connected. When a supply is given to the coil, it will produce an electromagnetic field across it, eddy current will generate on the track surface and the eddy current will generate another electromagnetic field of the track. The EMF generated by the eddy current on the track surface will oppose the EMF generated in the coil, so, due to the super imposition of the two opposing fields, the overall Ø of this system will decrease and, as we know $Ø = L \times I$ (L is constant for the particular coil i.e. Inductance) as Ø decreases I will also decrease as (Ø is proportional to I) and a decrease in I means increase in Z, i.e. the impedance. This impedance can be measured by a signal conditioning circuit and displayed on an oscilloscope. So, in, crack Free State. the eddy current produced is purely circular and EMF produced by the circular eddy current, the strength of the EMF will be much more but if there is crack in the track the Eddy current produced will not be circular and distorted in shape and because of the distortion in shape the strength of the EMF produced by the eddy current on the track surface will decrease, as EMF produced on track surface decreases, so overall Emf of the system will increase so as a result current will increase and as we know (Ø is proportional to I) Ø will also increase and as a result impedance will not increase that much it will increase by a little amount less than crack free impedance state, So by the increment value of the impedance we can see if the crack is there or not if there is a crack the increment of impedance value is not much higher but if there is no crack the impedance value will increase in much amount. But the system does not give accurate results as expected due to damping of electric current.

The other sensors that are used are LED and LDR sensors. The LED will be attached to one side of the rails and the LDR to the opposite side. During normal operation, when there are no cracks, the LED light does not fall on the LDR and hence the LDR resistance is high. Subsequently, when the LED light falls on the LDR, the resistance of the LDR gets reduced and the amount of reduction will be approximately proportional to the intensity of the incident light. As a consequence, when light from the LED deviates from its path due to the presence of a crack or a break, a sudden decrease in the resistance value of the LDR sensor. This change in resistance indicates the presence of a crack or some other similar structural defect in the rails. The common 5V LED and cadmium supplied LDR was found to be sufficient. The LED is powered using one of the digital pin of the microcontroller. The LDR and a 45kΩ resistor form a potential divider arrangement. The output of the potential divider is given to one of the analog input channel of the microcontroller. The LDR is calibrated every time the robot is used. The light dependent resistor or cadmium sulfide (CdS) cell is a resistor whose resistance decreases with increasing incident light intensity. The main drawback of the system is that the LED and LDR should be aligned properly i.e. exactly aligned opposite to each other to detect the crack.

For this reason, using ultrasonic sensors is the best decision, Ultrasonic sensors are available for the past many decades and these devices continue to hold huge space in the sensing market because of their specifications, affordability, and flexibility. As the automation industry has been progressing, the employment of ultrasonic sensors in multiple domains Ultrasonic sensors are electronic devices that calculate the target's distance by emission of ultrasonic sound waves and convert those waves into electrical signals. The speed of emitted ultrasonic waves traveling speed is faster than the audible sound. To know the distance between the target and the sensor, the sensor calculates the amount of time required for sound emission to travel from transmitter to receiver. Ultrasonic sensor has only one module that has both transmitter and receiver. Ultrasonic sensors emit short,high-frequency sound pulses at regular intervals. These propagate in the air at the velocity of sound. If they strike an object, then they are reflected back as anecho signal to the sensor, which itself computes the distance to the target based on the time-span between emitting the signal and receiving the echo signal. Alignment is not an issue with using this sensor.

III. CONCLUSION

Railway track crack detection is important so as to avoid accidents and derailments due to small cracks going unnoticed due to human involvement in track line monitoring. So, considering the above factors, the robotic railway track inspection vehicle using ultrasonic sensors stands out from the rest of the technologies as it gives output in terms of number rather than waveform, so it is easy to figure out exact output and also misalignment is not an issue as noticed in LED LDR sensor and is programmable to operate with proper precision and efficiency.

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