Design and Fabrication of Automatic Railway Track Crack Detection System

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Abstract

The Indian railway has one of the largest railway networks in the World, over 1, 15,000 km in distance. A recent study revealed a Fact that over 25% of the track length is in need of replacement Due to development of cracks on it. Manual detection of tracks is cumbersome and not fully effective. This project is done with Aim towards addressing the issue by developing an automatic Railway track detection system integrating an infrared IR crack Sensing module based on GSM technology by which information about the location of the crack can be conveyed to the central Location enabling immediate attention and intervention of the Maintenance personals. The whole construction of automatic railway track crack detection system consists of various components. It includes GSM module, GPS receiver, arduino board, GPS antenna, IR sensor, Battery and DC motor. The working platform for the whole system is Arduino board. The GSM module is interfaced with arduino through coding or programming. Similarly the GPS receiver is also interfaced with arduino through a specified program. The GPS i.e the global positioning system here plays a major role in the whole system, this is used to determine or to lock the exact location of the crack where the crack is being detected. The longitude and latitude of the exact crack location is determined through GPS antenna. The GSM Module also plays a vital role in the whole system. It is used to pass the message to the nearby station or maintenance center.

Keyword- Arduino, GPS, GSM

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I. INTRODUCTION

This is an era of automation where it is broadly defined as replacement of manual effort by Electronics in all degrees of automation. The operation remains an essential part of the system although with changing demands on physical input as the degree of mechanization is increased.

Degrees of automation are of two types, viz.

- Full automation.
- Semi automation.

In semi automation, a combination of manual effort and mechanical power is required whereas in full automation human participation is very negligible. Our project is fully automated one.

Automation can be achieved through computers, hydraulics, pneumatics, robotics, etc., of these sources, form an attractive medium for low cost automation. The main advantages of all automation systems are economy, accuracy and simplicity.

Automation plays an important role in all industries.

- To achieve Quick Response
- To reduce man power
- To increase the system efficiency
- To reduce the work load
- To achieve greater accuracy
- To reduce the time of operation
- To reduce the fatigue of workers
- To achieve good system quality
- Less Maintenance

II. LITERATURE REVIEW

Avinash.Vanimireddy1, D.Aruna Kumari et al said that the main problem about a railway analysis is detection of cracks in the structure. If these deficiencies are not controlled at early stages they might lead to a number of derailments resulting in a heavy loss of life and property.

Ramavath Swetha et al inferred the ideas in designing railway track crack detection autonomous vehicle using Microcontroller, IR obstacle Sensors assembly system, which detects the cracks along its path; the vehicle is also capable of monitoring the location of the crack by using the GPS module and alerts through SMS messages using GSM module.

III. COMPONENTS AND DESCRIPTION

The main components of the automatic railway track crack detecting vehicle are:
- IR Sensor
- Arduino
- GSM transmitter and Receiver Unit
- GPS
- GPS Antenna
- D.C. Motor
- Spur gears
- Railway Track
- Battery

A. IR Sensor
In our project IR transmitter and receiver circuit is used to sense railway track cracks. There are two pairs of sensor are used.
Sensor 1: One side of the train track Sensor 2: Other side of train track
Sensor 1 and Sensor 2 are used to sense the crack in the railway track and giving control signal to the GSM transmitter unit.

B. Arduino
Arduino is an open source computer hardware and software company, project and user community that designs and manufactures single board microcontrollers and microcontroller kit for building digital device and interactive objects that can be sense and control objects in the physical world.
The boards are equipped with sets of digital and analog input/output pins that may be interfaced to various expansion boards and other circuits.
The boards feature serial communications interfaces, including Universal Serial Bus on some models, which are also used for loading programs from the personal computers.
The microcontrollers are typically programmed using a direct of features from programming languages C and C++.
Common examples of such devices intended for beginner hobbyists include simple robots, thermostats, and motion detectors.

C. GSM Transmitter Unit
GSM transmitter unit is used to activate the receiver unit when the signal is received from the IR sensors.

1) Transmitter Circuit Description
The transmitter is made to activate with the supply from a 9volt battery. When IR sensor is giving the crack detection signals the voltage is supplied to the Frequency modulator. The frequency modulator modulates the base hand signal by using a proper carrier frequency. The output of the modulator is given to a high power amplifier to raise the modulated signal. This modulated signal is then fed to the transmitting antenna.

2) Receiver Circuit Description
The transmitted signal is received by the receiving aerial at the station master. The received signal contains unwanted energy, which is usually termed as noise. The noise affects the receiver sensitivity. So the noise should be filtered, this filtering is done by the low noise amplifier block. This weak signal is now amplified so that it turns the relay circuit ON (i.e.) to activate the main contractor.

D. GPS
Global Positioning System tracking is a method of working out exactly where something is. A GPS tracking system, for example, may be placed in a vehicle, on a cell phone, or on special GPS devices, which can either be a fixed or portable unit. GPS works by providing information on exact location. It can also track the movement of a vehicle or person. So, for example, a GPS tracking system can be used by a company to monitor the route and progress of a delivery truck, and by parents to check on the location of their child, or even to monitor high-valued assets in transit.

E. GPS Antenna
The GPS Antennas are used for the reception of RF signals from the Global navigation satellite system like GPS, GALILEO, Glonass, Beidou and omnistar.
In general there are two different designs for GNSS antenna: the patch antenna and helix antenna.

Patch antenna is a flat, quadratic, structured plat which is only a few centimetres in dimension. The antenna pattern is horizontally a circle and club- shaped in vertical.

F. D.C. Motor

In our project permanent D.C motor is used. An electric motor is a machine which converts electrical energy to mechanical energy. Its action is based on the principle that when a current- carrying conductor is placed in a magnetic field, it experiences a magnetic force whose direction is given by Fleming's left hand rule.

When a motor is in operation, it develops torque. This torque can produce mechanical rotation. DC motors are also like generators classified into shunt wound or series wound or compound wound motors.

When an enable input is high, the associated driver gets enabled. As a result, the outputs become active and work in phase with their inputs. Similarly, when the enable input is low, that driver is disabled, and their outputs are off and in the high-impedance state.

G. Body

Detection system consist of battery, motor and spur gear mechanism. One gear is fixed to the motor shaft and another one gear is fixed in the wheel shaft of the system.

1) Spur Gears

Spur gears are used to transmit power between parallel shafts. They impose only radial loads on their bearings. The tooth profiles are ordinarily curved in the shape of an involute. Variations in center distance do not affect the trueness of the gear in action unless the change is so great as to other jam the teeth into the root of the mating member or with draw the almost out of action. Spur-gear teeth may be hobbed, shaped, milled, drawn, sintered, cast, and shear-cut. They may be given a finishing operation such as grinding, shaving, lapping, rolling, and burnishing. Generally, there are more kinds of machine tools and processes available to make spur gears than to make any other gear type.

The spur gears, which are designed to transmit motion and power between parallel shafts, are the most economical gears in the power transmission industry.

a)   Application
- Material handling
- Feed drives
- Machine tools
- Conveyors
- Marine hoists

2) Internal Spur Gear

The internal gears are spur gears turned "inside out." In other words, the teeth are cut into the inside diameter while the outside diameter is kept smooth. This design allows for the driving pinion to rotate internal to the gear, which, in turn, allows for clean operation. Intended for light duty applications, these gears are available only in brass. When choosing a mating spur gear, always remember that the difference in the number of teeth between the internal gear and pinion should not be less than 15 or 12.

a)   Applications
- Light duty applications
- Timing
- Positioning
- Rollers
- Indexing

3) External Spur Gear

Perhaps the most often used and simplest gear system, external spur gears are cylindrical gears with straight teeth parallel to the axis. They are used to transmit rotary motion between parallel shafts and the shafts rotate in opposite directions.

They tend to be noisy at high speed as the two gear surfaces come into contact at once. Internal spur gears: The internal spur gear works similarly to the external spur gears except that the pinion is inside the spur gear. They are used to transmit rotary motion between parallel shafts but the shafts rotate in the same direction with this arrangement.

H. Railway Track

Railway track is made up of M.S.Steel materials. The length of the track is 12 feet. Train wheel is also made up of M.S Steel materials. The center of the wheel is V-grooved, so that the vehicle moves on the exact track path.

I. Battery

Material : Lead-Acid Battery Output Voltage: 12 V
Output Power: 7 Ampere-Hour

IV. DESIGN AND DRAWINGS

The main design considerations are Spur Gear and Bearings.

A. Spur Gear
Diameter of the motor gear wheel (D1)
= 36 mm
Diameter of the Shaft Gear Wheel (D2) = 72mm
Speed of the Motor (N1) = 60 RPM Speed of the shaft wheel (N2)
= (D1 / D2) x N1
= (36 / 72) x 30
= 15 RPM

B. Bearing
Bearing No. 6202
Outer Diameter of Bearing (D) = 35 mm
Thickness of Bearing (B) = 10 mm
Inner Diameter of the Bearing (d) = 15 mm
$r_1 =$ Corner radii on shaft and housing
$r_1 =$ 1(From design data book)
Maximum Speed =14,000 rpm (From design Data book)
Mean Diameter (dm) = (D + d) / 2
                = (35 + 15) / 2
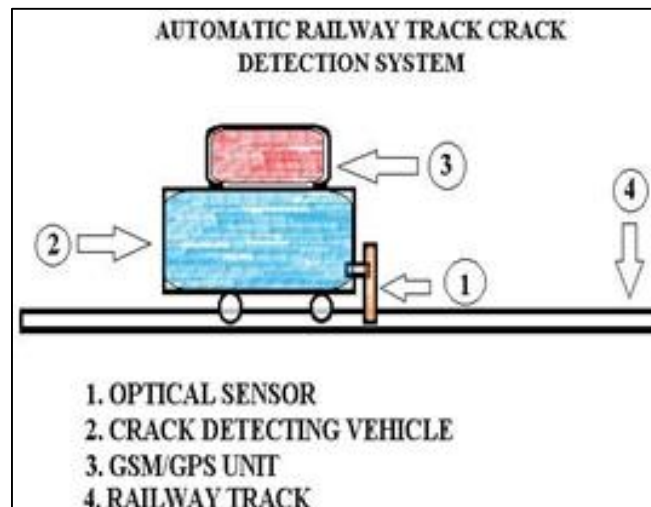   Dm =25 mm

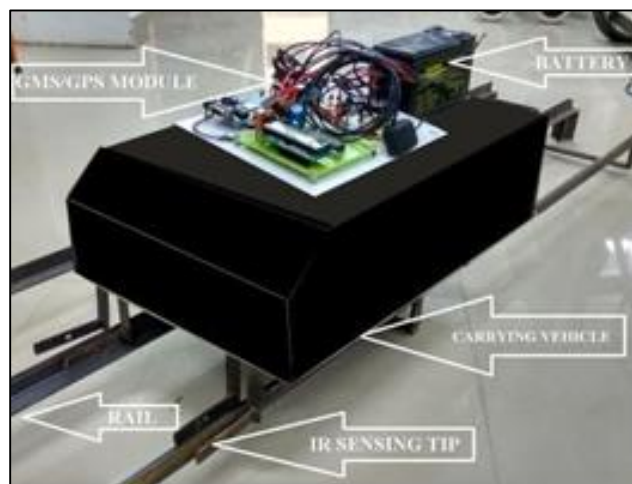Fig. 1: Automatic Railway Track Crack Detection System

Fig. 2: Fabricated Model of Automatic Railway Track Crack Detection System

V. WORKING PRINCIPLE

In our project, there are two set of IR sensor units fitted to the two sides of the vehicle. This unit is used to activate/deactivate GSM transmitter unit when there is any cracks in the track.

The IR transmitter and IR receiver circuit is used to sense the cracks. It is fixed to the front sides of the vehicle with a suitable arrangement.

A. At Normal Condition

The IR transmitter sensor is transmitting the infrared rays with the help of 555 IC timer circuit. These infrared rays are received by the IR receiver sensor. The Transistors are used as an amplifier section. At normal condition Transistor is OFF condition. At that time relay is OFF, so that the vehicle running continuously.

B. At Crack Condition

At crack detection conditions the IR transmitter and IR receiver, the resistance across the Transmitter and receiver is high due to the non-conductivity of the IR waves. So the output of transistor goes from OFF condition to ON stage. In that time the relay is ON position. In that time, the motor power supply is disconnected and switch on to the GSM transmitter unit. The GSM receiver is fixed to the nearest station master, so that the alarm signal is given to the station master.

VI. FLOW CHART

VII. ADVANTAGES

- The auto crack detection method is more efficient in the technical field
- Quick response is achieved
- Simple in construction
- Easy to maintain and repair
- Cost of the unit is less when compared to other
- No fire hazard problem due to over loading
- Comparatively the operation cost is less
- Continuous operation is possible without stopping

- Automatic alert system to the station master
- The signal transmission is wireless transmission.

VIII. APPLICATIONS

A. Automatic crack checking
The vehicle draws power from the battery. The IR sensor is used to detect the crack in the railway track. Suppose any crack in the track, the vehicle automatically stop and activates the GSM transmitter circuit.

B. Cordless identification to the station master
This unit can also be used to intimate the nearest railway station. The GSM receiver circuit is fixed in the room of the station master.

IX. DISADVANTAGES

- The signal transmission is below 50 feet
- The vehicle operated in battery power, so rechargeable battery is used to drive the vehicle.

X. CONCLUSION

By using this automatic vehicle for purpose of railway track inspection and crack detection, it will have a great impact in the maintenance of the tracks which will help in preventing train accidents to a very large extent. The regions where manual inspection is not possible, like in deep coal mines, mountain regions and dense thick forest regions can be easily done using this vehicle. By using this vehicle for the purpose of railway track inspection and crack detection and automated SMS will be sent to pre-defined phone number whenever the vehicle sensors detect any crack or deformation This will help in maintenance and monitoring the condition of railway tracks without any errors and thereby maintaining the tracks in good condition, preventing train accidents to very large extent railway track crack detection autonomous vehicle is designed in such a way that it detects the cracks or deformities on the track which when rectified in time will reduce train accidents. The addition of solar panel is an added advantage, which also helps conserving the power resource.

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