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Implementation of Automated System to Detect Cracks in Rails

Ajin M, Raghvan T, Pallavarajavarman R

Dept. of Mechanical Engineering, Rajalakshmi Engineering College
Thandalam Chennai.

Abstract
Technology has become an integral part of life due to which there are innovations and jobs created daily. This technology has changed the way we live. It has brought improvement in everything around us, including the field of travel, because the need for men and material has increased in recent years. Transport plays a significant role in the functionality of industries because it provides the raw material, and it helps in the transport of the finished goods after production. One of such major transport modes is railways; it helps in speedy and mass transportation of both men and materials for the industries. But due to the daily usage and poor maintenance of railways track, it may lead to the formation of crack or breakage, which will stand as a barrier for safety. As the railway network present in a nation is very large, manual inspection of each track is impossible. So, various methods are present for inspection of the track,including both destructive and non-destructive techniques. As the destructive technique needs collection of samples, mostly Non-Destructive Techniques (NDT) methods are used. One such method is the ultrasonic testing method, which helps testthe railway track without any loss; in this method, the high-frequency sound is used to diagnose the track, which gives a highly précised value. To reduce time and human effort, this method is combined with a live robot for automatic inspection. This helps in the development of the solution to any problem that has been encountered.

Keywords —*Non-Destructive techniques, Ultrasonic testing.*

I. INTRODUCTION

Manual detection of cracks is a traditional method of detecting defects in the railway lines. This method of .detection is not fully effective, owing to much time consumption and skilled technicians' requirement. To overcome this, Non-destructive testing (NDT) methods are introduced. In this method, the process of inspecting, testing, or evaluating materials, components, or assemblies for discontinuities or differences in characteristics is carried out without destroying the serviceability of the part or system. Other tests are destructive and are therefore done on a limited number of samples, rather than on the materials, components, or assemblies being put into service. But discontinuities and differences in material characteristics are more effectively found by NDT. The types of test methods vary with the penetrating medium and the equipment used to perform that test. The most frequently used test methods are MT, PT, RT, UT, ET, and VT. In this project, we used the Ultrasonic method for railway track inspection.

II. COMPONENT DESCRIPTION

Ultrasonic Testing (UT) makes measurements used for flaw detection or evaluation, dimensional measurements, material characterization, etc., using high sound frequencies for testing. Chief components used in this UT testing are a testing machine (flaw detector), a vehicular robot, Arduino mega 2560 microcontroller, dc motor, a DC battery (12V, 2A).

A. Motor Driver Circuit

In electronics, a driver is an electrical circuit or other electronic component used to control another circuit or component, such as a high-power transistor, liquid crystal display (LCD), and numerous others. A motor driver is a little current amplifier; motor drivers' function is to take a low-current control signal and then turn it into a higher-current signal that can drive a motor.

B. X-Y Linear direction motion

The linear mechanism is a mechanism in which the rotary motion is converted into a linear motion. In this mechanism, the rotary motion of the motor is converted into the linear sliding mechanism. A slider is used to achieve this sliding mechanism. X-Y linear mechanism represents the direction of the slider both in the X and Y direction. One slider is used to move in the X direction, and another one is used to move in the Y-direction. Both sliders are paired to achieve the X-Y linear mechanism.

III. DESIGN DRAWING

A. Isometric View

It explains the basic layout of our robot on the railway track shown in Fig. 1. The structure is divided into two parts – The Upper portion housing the Ultrasonic Machine and Wheels, and the Lower portion housing the XY Linear Mechanismshpwn in Fig. 2. The two sections can be detached from each other and carried

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separately, thus allowing effortless dismantling. The mechanism consists of two sliding motion pairs combined to allow movement on both X and Y axes. The probe is fixed on the green link, as shown in the diagram, and this mechanism can be raised or lowered vertically and can be moved perpendicular to the axis of the track.

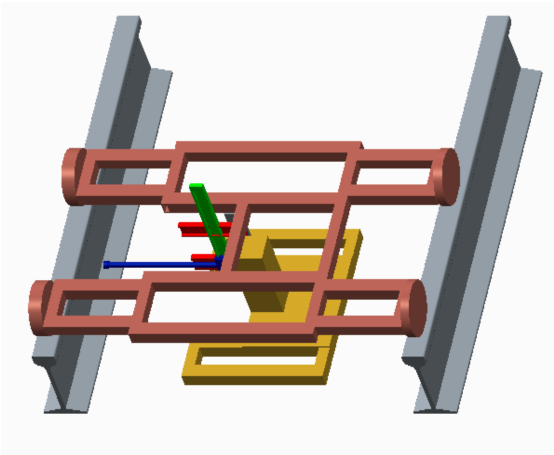

Fig. 1

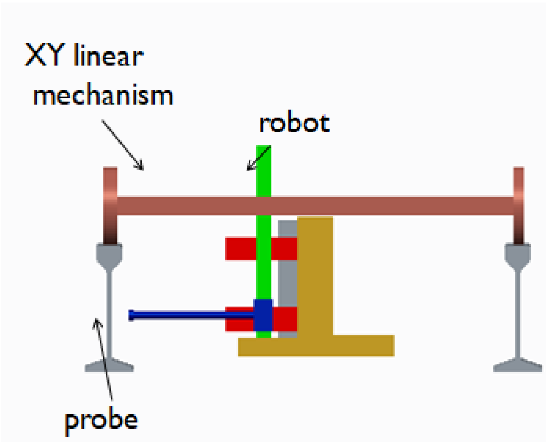

Fig. 2

IV. DESIGN LAYOUT

A. Chasis

As shown in Fig. 3, the Chassis consists of hollow mild steel tubes of thickness 2.5mm welded together to form a rigid support structure. The Chassis can withstand the lateral and vertical forces acting on it.

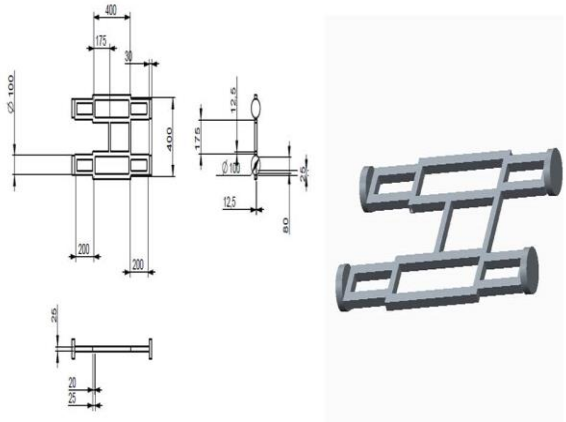

Fig. 3

B. Mechanism Housing

This part of the robot houses the XY Linear Mechanism. A series of linkages made of Mild Steel tubes of thickness 0.15mm shown in Fig. 4. This housing is connected to the Chassis by means of 3 pillars with plates at the top. The housing is bolted to the Chassis, thus allowing the dismantling of the robot. It is also set at a height convenient enough to allow inspection of the tracks with ease.

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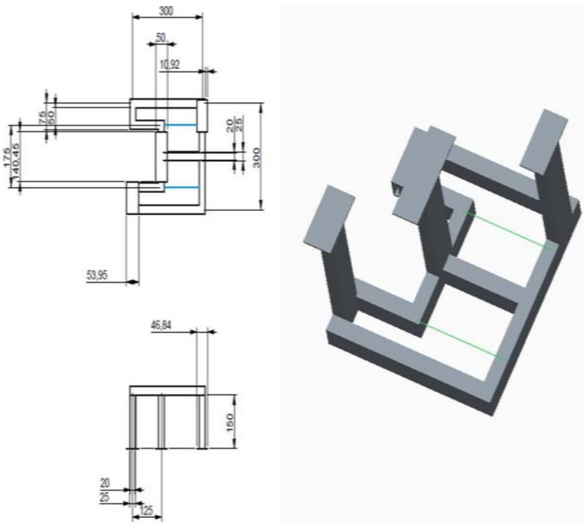

Fig. 4

V. ANALYSIS OF CHASIS

The Chassis is then subject to displacement analysis using ANSYS software through the evaluation of its structural capabilities. The following analysis confirms that the Chassis can withstand upwards of 15kg of the load acting on it while allowing the wheels' free lateral movement shown in Fig. 5.

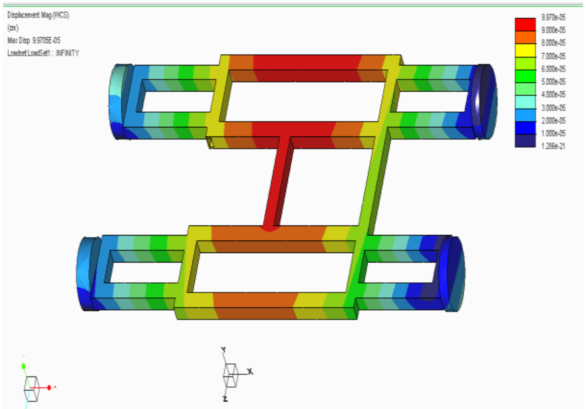

Fig. 5

VI. DESIGN CALCULATION

A. Speed calculation of the motor

$$N = \frac{P \times 60}{2\pi T}$$

Where N = speed of the motor (rpm), T = Torque (N-m), P = Power of the motor (W).

$$T = F \times r$$

where, F = Force (N) $= m \times g$, m = Mass on the wheel, (10 kg), g = Acceleration due to Gravity, (9.81m/s^2), r = Radius of the wheel, (0.0375 m)

$$T = 3.67N - m$$

$$P = V \times I$$

where, V = Voltage (12V), I = Current (3A).

$$P = 12 \times 3$$

$$P = 36W$$

$$N = \frac{P \times 60}{2\pi T}$$

Where P = power of the motor (W), N = speed of the motor (rpm), T = Torque (N-m).

$$N = \frac{36 \times 60}{2 \times 3.14 \times 1.839}$$

N = 93.7 rpm.

The required speed of the motor is 93.7 rpm. So, the 100-rpm motor is selected.

B. Ultrasonic Testing Calculation

TABLE I

S.No.	Topic	HighFreq.	Low Freq.
1.	Depth of penetration	Low	High
2.	Sensitivity	High	Low
3.	Near Zone	High	Low
4.	Beam Speed	Low	High

C. Sensibility

$$\text{Sensibility} = \frac{v}{2f}$$

where, ɳ = depth of penetration, v = velocity (600 ms^{-1}), f = frequency (4 MHz), D = diameter of the probe (10mm).

$$S = \frac{600}{2 \times 4 \times 10^6}$$

$$S = 0.75 \text{ m}$$

D. Near Zone

$$\text{Depth of penetration } \eta = \frac{v}{f}$$

$$\eta = 1.5 \times 10^{-3}$$

$$\text{Near Zone N} = \frac{D^2}{4\eta}$$

$$N = \frac{0.01^2}{4 \times 1.5 \times 10^{-3}}$$

N = 16 mm

E. Drive Wheel Motor Torque Calculations

It is always necessary to calculate the force applied between the tire and inclined surface to move a robot,

Gross vehicle weight, R_G: 10 kg (98.1 N)

Weight on each drive wheel W: 24.5 N

Radius of wheel/tire R_D : 0.0375m (37.5 mm)

Preferred top speed S_M : 0.1 m/s

Preferred acceleration time T : 5 S

Maximum incline angle, α : 2^0

Working surface : Dirty/sandy

Friction Coefficient : 0.4

Rolling resistance is the force necessary to drive a vehicle over a particular surface.

Rolling Resistance (RR) = W× RD

RR = 3.62 N

Grade resistance is the amount of force necessary to move a vehicle up a slope.

Grade resistance (GR) = W×sin α

GR = 3.423 N

Acceleration force is the force necessary to accelerate from a stop to maximum speed atthe desired time.

Acceleration force (AF) = (W×S_M)/(T×g)

AF = 0.2 N

F. Determination of Total Tractive Effort

The total tractive effort is the sum of the force necessary to overcome rolling resistance. It is necessary to move a vehicle upon a slope and force necessary to accelerate to the final maximum speed atthe preferred time.

Total Tractive Effort (TE) = RR+GR+AF

TE = 7.243 N

G. Determination of wheel motor torque

To verify the vehicle will perform as designed regarding tractive effort and acceleration, it is necessary to calculate the required wheel torque based on the tractive effort.

$$\text{Wheel Torque, TR (N-m)} = \text{TE} \times \text{RG} \times \text{Resistance Factor}$$

The resistance factor accounts for frictional losses between the wheels and their axles and the drag on the motor bearings. Typical value range between 1.1 and 1.15.

$$\text{TR} = 7.243 \times 0.0375 \times 1.1$$
$$\text{TR} = 0.298 \text{ N-m}$$

To verify that the vehicle can transmit the required force from the drive wheel to the ground, the maximum tractive torque a wheel can transmit is equal to the normal load times the friction coefficient between the wheel and the ground times the drive radius wheel.

$$T_{max} = W \times \mu \times RG$$
$$T_{max} = 0.413 \text{ N-m.}$$

Since the total wheel torque calculated is less than the sum of the Maximum Tractive Torques for all drive wheels, the slipping will not occur.

VII. WORKING

A. *Control Mechanism*

The below-given circuit is the actual basic layout of the electronic infrastructure employed in the robot. The circuit consists of the Arduino Mega 2560, which acts as the circuit's brain as all commands are compiled and executed through this component.

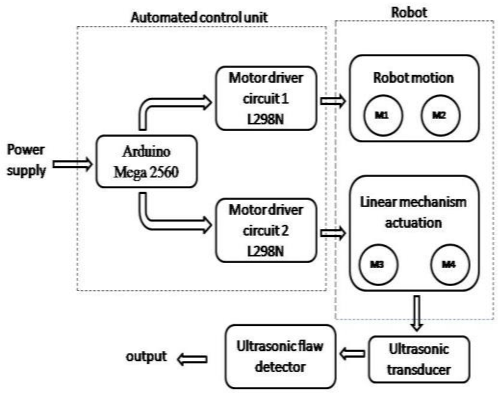

Fig. 6

B. *Robot*

The robotic movements are controlled by 2 dc geared motors of 100rpm. At first, the robot moves forward for a certain period, and the robot stops when the linear mechanism starts, where the probe moves either up or down and right or left to the fixed position in the track. After that, the robot moves in the reverse direction. The XY linear mechanism is controlled by the other two dc motors connected to it. It operates for a certain period when the robot is stationary. Thus, this operation is done continuously for various lengths of track.

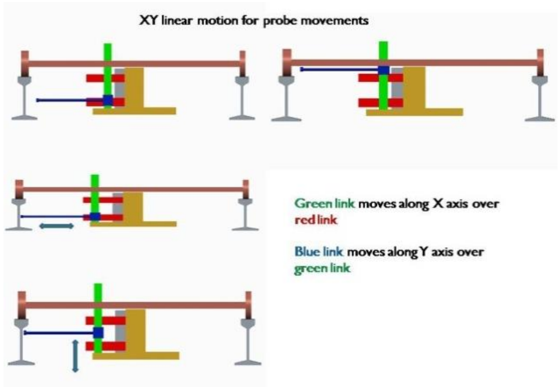

Fig. 7

C. *Automatic Control Unit*

It consists of Arduino Mega 2560, two L298N motor driver circuits, breadboard, and battery. The connections are given, as shown in the figure.

Conditions for robot control:M1 & M2 – Robot motion control*;* M3&M4 – linear mechanism;

TABLE II

Motor	Condition	Time delay
M3	Forward	3 seconds
M1 & M2	Forward	6 seconds
M3	Reverse	3 seconds
M4	Forward	3 seconds
M3	Forward	3 seconds
M1 & M2	Reverse	6 seconds

The period is selected based on the length of the track. In this project, we used a track of length 1m. Similarly, the period can be adjusted for various lengths of the track.

D. *Fabrication Work*

Since we are fabricating the prototype, the real track width ratio is considered, and robot design is constructed. The robot is fabricated based on the created design, and corrections are made for the required output. The fabrication process involves the correct alignment of the various parts together according to the various parameter discussed. The various views are given below.

1) *Chasis*

The top part of the Chassis is made of a mild steel hollow tube of dimension (20×20mm and 1mm thickness). It is cut as per the measurements and joined using a gas welding process. The Chassis's bottom part is made of mild steel hollow tube of dimension (20 ×10mm and 0.5mm thickness). It also joined using a gas welding process. The top portion and bottom are connected by temporary connectors using fasteners. Thus, suitable holes are created by using drilling operations. The drill bit size of 6mm is commonly used for all holes.

2) XY Linear mechanism

The linear mechanism is fabricated and assembled by combining two separate single linear mechanisms and arranged in x and y directions. 8.

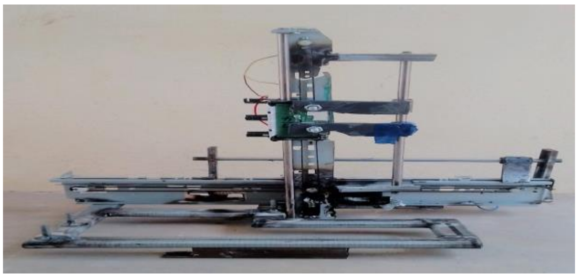

Fig. 8

3) Wheels

Wheels are made up of polyurethane material of diameter 75mm. These wheels are connected to the Chassis using connectors. The front wheel's connector is welded to the Chassis, which acts as a stud axle for the wheel. The connector for the rear wheel is connected to the motor shaft using a tight fit.

VIII. EXPERIMENTAL SETUP

A. Robot Setup

The experimental setup of the robot is shown in Fig. 9. The setup consists of the Arduino, which controls the motors, and the Motor driver circuit, which helps control the Arduino motor-assisted. The battery is also attached to the setup to give the motors and the Arduino the power supply. The ultrasonic testing machine is placed over the Chassis center, and the probe is attached to the linear mechanism.

Fig. 9

B. Testing of Robot and Evaluation

Ultrasonic test methods provide quantitative information regarding the component's thickness, depth of an indicated discontinuity, size of discontinuity, etc. The output data is viewed through a small web camera that is collected, and the defects are identified throughthe image processing system, as shown in Fig. 10. It involves a comparison of predefined data with acquired data, and results are accomplished.

When a machine detects the crack or a discontinuity in the railway track, the high peak was shown in the machine that informs a crack's detection. Due to the sensibility of the Ultrasonic testing, even a minute crack inside the track can be selected.

Fig. 10

REFERENCES

[1] Ee. Nisthul – Assistant professor, saint gits college of engineering. Lijo George, Nithin john – Students, Automatic Railway Track crack detection system, Imperial journal of interdisciplinary research. 3(4) (2017).

[2] N.karthik,Knanamani college of technology,Namakal, India on , Implementation of railway crack detection and protection, in International journal of engineering and computer science. 6(5) (2017).

[3] Sireesha R, Ajay Kumar B, Mallikarjunaiah G and Bharath Kumar B, Broken Rail Detection System using RF Technology, SSRG International Journal of Electronics and Communication Engineering, 2(1) (2015) 6-10.

[4] V.Muralidharan,V.Dinesh ,Kings Engg College, Coimbatore, an enhanced crack detection system for railway tracks, International Journal of Engineering Trends.21 (6) (2015).

[5] Mr.Prashanth.addagatla,Mr.G.Koteshwr Rao, A modern method for detecting cracks in railway tracks by efficient utilization of LDR and LED system, International journal of engineering science Innovation.

[6] B.Siva Rama Krishna, D.V.S.Seshendra, G.GovindaRaja, T.Sudharshan, K. Shrikanth, Railway track fault detection systems using IR sensors and Bluetooth technology, Asian journal of applied science and technology. 1(6) (2017).

[7] SaurabhSrivastava,RaviPrakashChaurasia, Prashant, Syed Imran Abbas, Prashant Sharma, Nitin Kumar Singh, Railway Track Crack Detection Vehicle, International Advanced Research Journal in Science, Engineering, and Technology. 4(2) (2017).

[8] Shailesh D. Kuthe, Sharadchandra, A. Amale, and Vinod G. Barbuddhye - ,Smart Robot for railway track crack detection system using LED- Photodiode Assembly,(Advance Research in electrical and electronic engineering,.(2015).