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INBUILT WEIGHING MECHANISM WITH OVERLOAD SAFETY CONTROL FOR TRUCKS USING IoT

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ABSTRACT

The transportation is a vital part of a society for a secured transportation system. Even though there are many factors which causes accidents but a majority of them are caused because of overloading. First of all, the maximum weight that a truck can carry are defined by the manufactures at the time of production unfortunately the drivers overload the vehicle for their convenience. Due to overloading the performance of the vehicle is greatly affected. The fuel efficiency and the overall life span of the vehicle will be reduced when it is overloaded. By using this method, the load carried by the vehicle is measured by using inbuilt weighing mechanism and it is continuously monitored from remote location. The load cell is used to measure the load carried by the truck. Arduino is used as data acquisition where GPS module is responsible for location and Wi-Fi module is used to send the load and location of vehicle to internet server (or) web server. The web server has the complete history of the truck and control unit is protect the truck from overload. The objective is to reduce the accidents caused by overloading of trucks and to find out the loss of goods during transportation. Wireless monitoring of truck location and load status from an unknown location is possible by using this method. It will reduce the pollution caused by the overloading of truck during transportation.

Keywords: load cell, arduino, GPS module, internet, Wi-Fi module.

1. INTRODUCTION

The idea of this study is to use a weighing machine inside the vehicle instead of searching weighbridge every time and also to protect from overloading. Even in this fast-growing world still we are searching for a weighbridge to measure load in vehicle, it is looking like waste of time and money. Also overloading in vehicle is one of the main reasons for most of the accidents. This project consists of two parts; weighing machine to monitor load continuously and sharing location and weight in internet. Inbuilt weighing machine concept is based on the principle of load cell weight measurement, thus load in the container is measured directly by fixing load measurement (based on compression) device at four edges and center of container. Also load value will be displayed continuously in internet server along with the location of vehicle. By implementing this concept, the expense paid to weighbridge for measuring the load will be avoided and drive, owner can watch the load status whenever needed. It will also avoid theft during transportation of goods. Accidents due to overload will be avoided and also vehicle security will be maintained.

PROBLEM DUE TO OVERLOADING

Road: The damage will be more severe if the vehicle travelled for a long distance with overloaded goods. The truck overloaded with heavy goods causes damage to roads along with decreasing the lifetime of roads.

Environment: According to Central Road Research Institute (CRRI) and the Indian Federation of Transport Research and Training (IFTRT) more toxic gases are emitted from a truck which is loaded over the maximum capacity.

Vehicle: The fuel efficiency and the overall life span of the vehicle will be reduced when it is overloaded. The overloading causes many hardware damages to the vehicles as a result maintenance cost of the vehicles will increase.

Security: The goods placed in the truck during transportation have no security. There is a possibility of theft during transportation.

Accident: When the truck is travelling with heavy load then there is a chance of getting accident is quite high. It becomes difficult for the driver to control the truck.

Society: The weight of the goods transported by a truck can greatly affect the safe driving. There will be lot of smoke produced by the overloaded truck which leads to air pollution in atmosphere.

Time: It becomes difficult for the overloaded truck to maintain proper speed and to reach destination on time.

Figure-1. Accidents Due to Overload.

Figure-2. Search of Weighing Bridge.

2. LITERARY REVIEW

When a vehicle is loaded with goods then the driver has to visit the nearby weighing bridge centre to measure the load. There are many drawbacks for this system. This method is time consuming and the driver has to pay each time when the load is measured. If overloading is detected the driver has to remove the goods and has to arrange another vehicle for carrying back the removed goods. The suspension systems of automobiles and trucks are designed to support the comfort and safety of human occupants. During the travel the chances of accidents is higher and more toxic gases are emitted by the vehicle if it is overloaded. There are many chances of brake failure when the truck is overloaded. There is no system to verify the load status of a truck instantaneously from remote location which cause more stoppage time in each check post. There is a possibility of theft or missing of goods during the transportation and it cannot be identified by both the owner and the driver till the destination reaches.

By using these methods load values are not accurate and faking of data are possible. Due to these reasons most of the drivers will skip the process. In some places these weighing bridges are placed in check posts and highway entries but this is not a reliable method. Because it will take more than ten minutes for a vehicle thus it causes traffic block and other disturbance to the public.

3. PROPOSED METHODOLOGY

The proposed system consists of a weighing machine which is inbuilt in the vehicle. The inbuilt weighing machine concept is based on the principle of load cell weight measurement. A pair of load cells are placed on the bottom side of the carrier such that the load can be measured and analyzed. The measured load is displayed continuously to driver using a digital display. The system consists of load cell kept below will able to measure the weight of the goods and using the Wi-fi module connected with Arduino board coded with Arduino program the weight measured will be transmitted to the internet server. Using the mobile app along with the channel id provided the user can monitor the weight carried by the vehicle. So, the excess weight also monitors and cautioned. Here we also place GPS (Global Position Satellite) in the vehicle so position is also Monitor by user along with weight in app which provide additional security to vehicle. The block diagram for the inbuilt weigh machine with overload safety for vehicles. In the container there will be six load cells placed below to measure the accurate weight along with GPS module to track the exact position of the vehicle the weight and the location will be updated in the internet server and also the past history of the vehicle can also be tracked. Which is an additional feature to the system. The size of the load cell and the GPS module is small and compact.

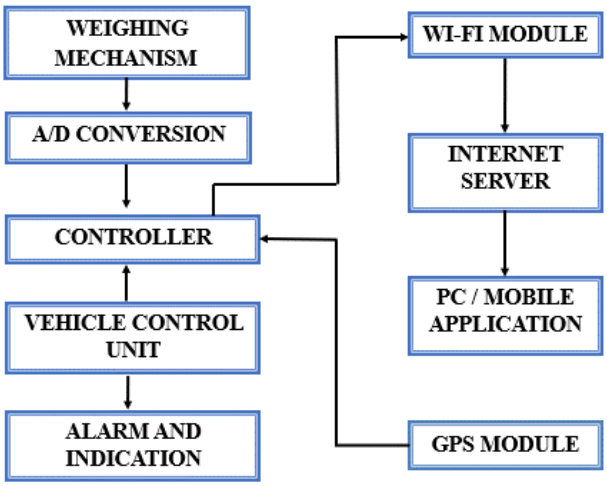

Figure-3. Real Time Load and Location System Block Diagram.

The flow diagram shows overall process of working, when the load placed in the vehicle is overloaded the vehicle will not able to move while it's in motion the location vehicle will be updated but not the weight since weight measured in motion will not be accurate so weight will be measured in the rest position. There will be a vehicle control unit which measures load placed in truck when overloaded the vehicle motion will be restricted while load reaches maximum alarm indication will be intimated to driver and the recommended user. The measured weight and location will be transferred to cloud. the vehicle control unit can also display the load and location in drivers' front panel. The data in the cloud can be seen in webpage or mobile application.

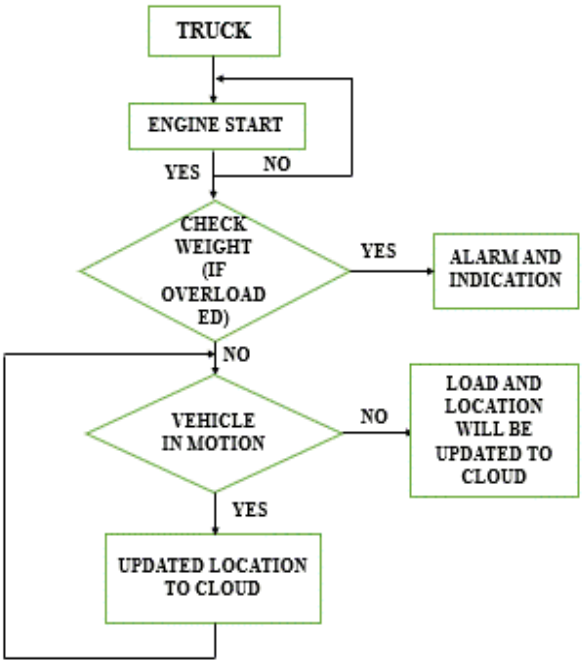

Figure-4. Flow Chart of Load Monitoring and Control Algorithm.

LOAD CELL CONVERSION

The load placed on load cell will be converted to digital value by means of conversion factor which is given by,

When the rated output is 1 mV/V and the excitation voltage is 9 V, the load cell will output 9 mV to the indicator. This is the output voltage. When the rated capacity of 5kg is loaded. (Load) 5kg → 9 mV (Output Voltage)

1:5000 = X:9 mV
5000 * X= 1 * 9 mV
X= 9 mV / 5000 ➔0.0018 mV

ACCURACY MEASUREMENT FACTOR

Load cell specifications must be checked to ensure accuracy factor of load cell. The factors that influence accuracy are nonlinearity, hysteresis error, repeatability, and temperature effects on zero balance and span. Now it's more common to express nonlinearity, hysteresis error, and repeatability together as the combined error. In order to measure accuracy of load cell is given by,

$$\mathcal{E} = \sqrt{\varepsilon_c^2 + \left(\frac{\varepsilon_2 * L * N}{w_1} * t\right)^2 (\varepsilon_5 x_t)^2}$$

ε : Measurement accuracy of the load cell (%)
εC : Combined error (%)
εZ : Temperature effect on zero balance (%/˚C)
εS : Temperature effect on span (%/˚C)
L : Rated capacity of the load cell

The above formula is used to calculate the percentage of error factor in load cell which needs to know before implantation of load cell in particular areas.

The weight measured by each load cell will be calculated using average-median method,

$$= \frac{1}{n}\sum_{i=0}^{n} a_i = {}^{1}/_{n}\,(a_1 + a_2 + \cdots + a_n)$$

Where,
n is the number of load cell placed,
a is the weight measured by each load cell.

From monthly statistics the average weight carried by the truck per day,

$$= \frac{1}{n}\sum_{i=0}^{n}(w_1 + w_2 + \cdots + w_n)$$

Where,
n is the number of days in month.
w is the total weight carried by the truck.

The above table diplays error factor of load cell when load placed in truck increases error factor decresases or vice versa. The error factor is calculated by,

%error = (DL – AL) *100 / AL

Where,
DL is Displayed Load after loading,
AL is Actual Load placed inside the truck.

Table-1. Experiment of error.

S. No	Actual Load	Displayed Load	Error (%)
1	50	51.8	3.6
2	75	77.4	3.2
3	100	98.6	3.2
4	125	127.1	1.6
5	150	148.8	0.8

The Graph shows the actual load that placed inside the truck and the displayed load after loading process. The error occurred during the process is plotted in graph representation and it is calibrated.

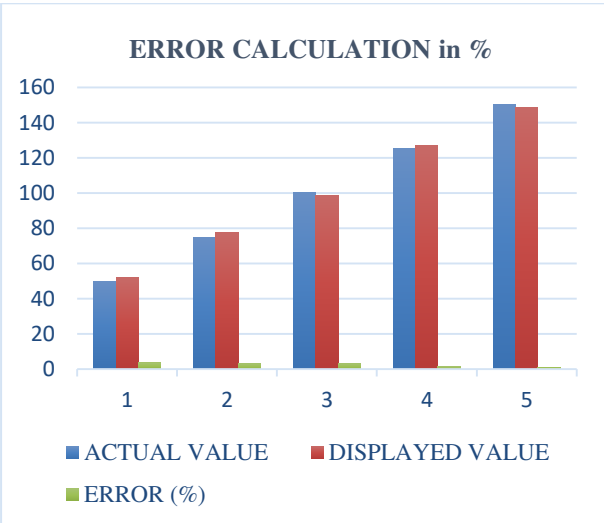

Figure-5. Graphical analysis of error.

4. MECHANICAL DESIGN AND EXPERIMENTAL SETUP

This setup consists of load cell at base covered by another base where loads are being placed. It also contains GPS device to locate position of vehicle in remote areas. All devices are controlled by chip board which serves as the main controller where datum collected by load cell, GPS are collected and transmitted to Wi-Fi module which updates collected data to internet server which acts as database to manipulate data for further proceedings.

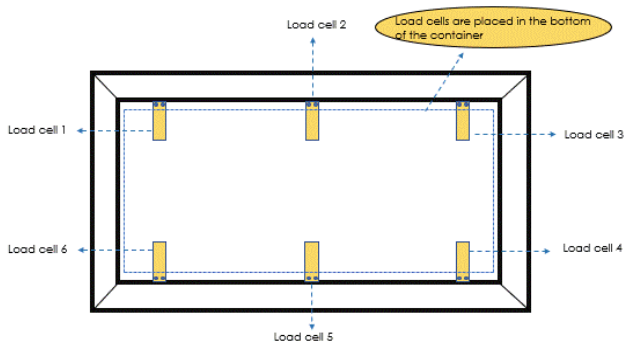

Figure-6. Load Cell Arrangement.

In this there will be four load cells are placed at the edges and two at mid of the container to measure the accurate weight and it is covered by a base to prevent load cell damage

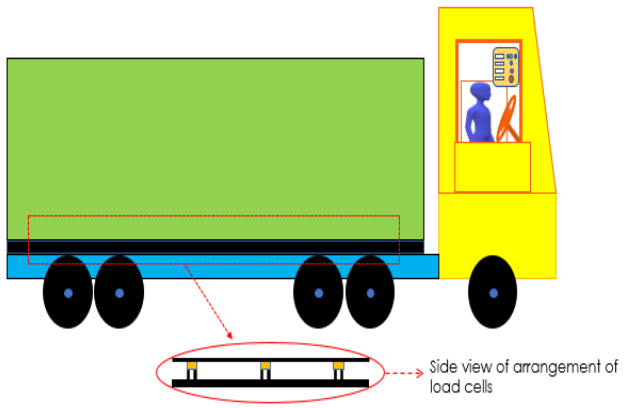

Figure-7. Load Cell Setup.

This is the side view of load cell setup inside the container and it is covered by the base. The load is only measured when the rpm of truck is zero i.e. truck is in stationary position.

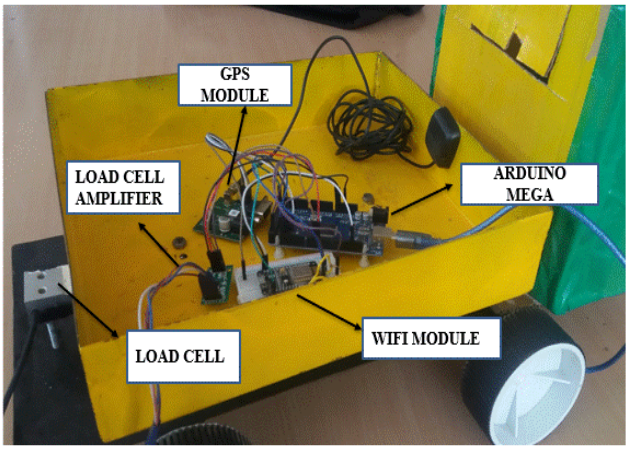

Figure-8. Experimental Setup.

5. RESULT AND DISCUSSIONS

Output results shows that the load carried by the truck is displayed in the webpage and it is also viewed by owner through mobile application. The overload indication of truck is notified in driver's front panel.

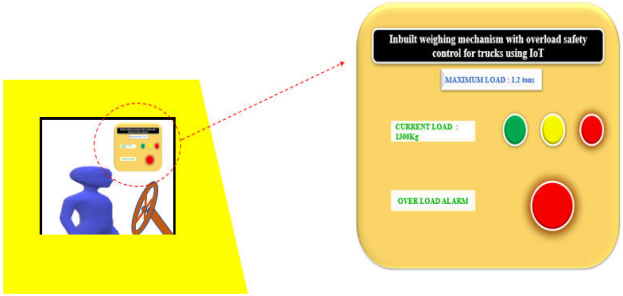

Figure-9. Overload Indication in Driver's Front Panel - Truck OFF Condition Not Allowed to Move.

Overload Indication in Driver's Front Panel - Truck ON Condition (Allowed to Move). Overload indicator will be placed inside drivers' panel where indication weight being placed in truck will be displayed in order to ensure safety of vehicle.

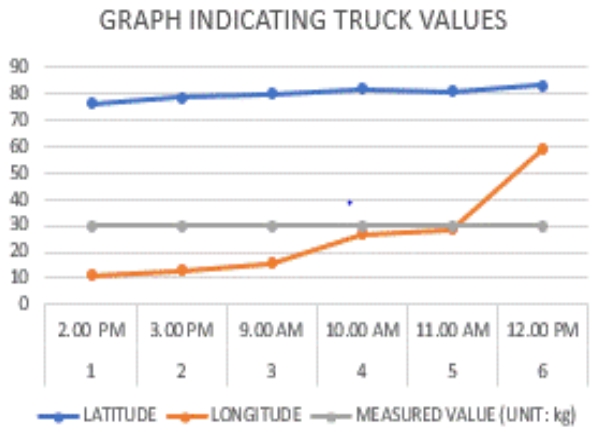

Figure-10. Graphical Representation of data's in server.

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The above graphs display latitude and longitude along with time and location of vehicle which indicates database of vehicle along with indication for calibration of load cell or indication of service to vehicle. With the help of database, the total time travelled along with total distance and weight carried by vehicle can also be tracked with past history of location which may increase safety and security to vehicle

The table contains the datum of experiment during testing and information about location of vehicle along with the weight being placed in truck meanwhile contains the time of vehicle during transportation. The above graph is collection of data from the web server database its in the form pgn data file which is converted into graph display in the above form where the data is of from different time to time along with load value and the latitude and longitude of truck with the current position.

Table-2. Experimental Data.

TIME	LATITUDE	LONGITUDE	WEIGHT
2.00 PM	76.452378	11.125489	30
3.00 PM	78.567854	13.146575	30
9.00 AM	79.974562	15.576442	30
10.00 AM	81.958748	26.578942	30
11.00 AM	80.96548	28.588435	30
12.00 PM	82.984756	58.799522	30

The below graph displays statistics value of total distance travelled by truck during each month which may be useful for calculation of statically value.

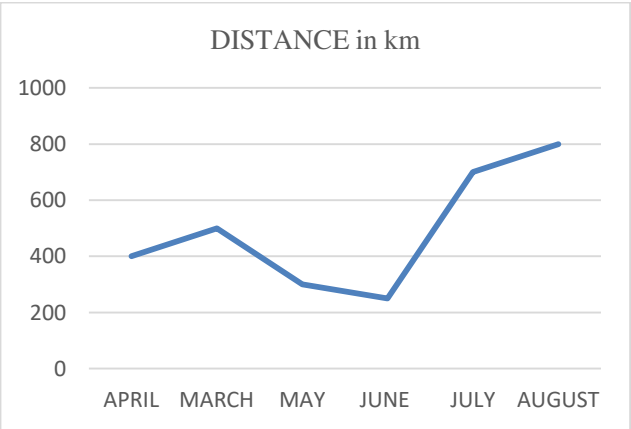

Figure-11. Distance travelled by the truck.

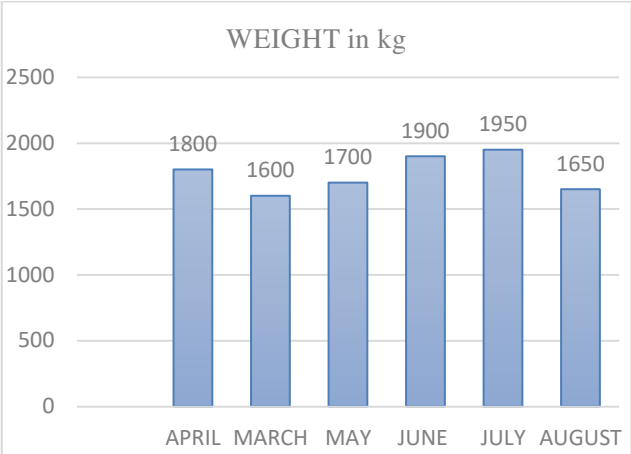

Figure-12. Load carried by the truck.

The above graph displays statistics value of total weight carried by truck during each month which may be useful for calculation of calibration of load cell.

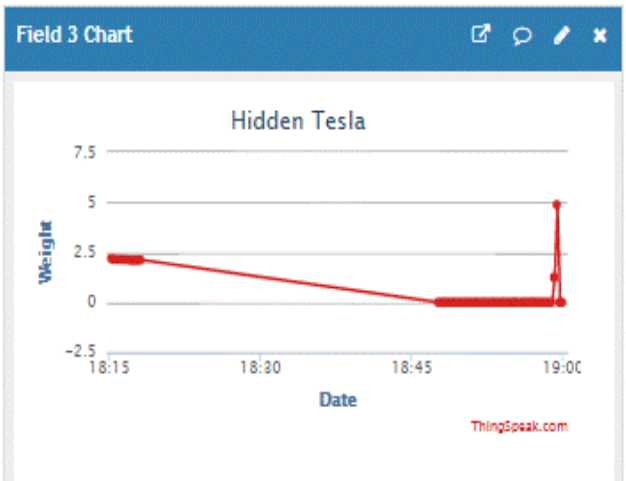

Figure-13. Load in Truck.

The above graph is displaying weight measured by weighing transducer in truck and value is displayed in graphical representation.

Figure-14. Latitude and Longitude Value.

Location of vehicle is sent to server in terms of latitude and longitude, received data is plotted in terms of graph the above value latitude and longitude gives exact location of vehicle.

5. CONCLUSION AND FUTURE SCOPE

In these experimental studies, a weight measurement method based on load cell methodology in vehicle is studied and validated. It incorporates GPS, weight measurement. Depending upon the weight the vehicle security is monitored and tracking of the vehicle is also possible for better accuracy and also ensure the security, also prevent the accident due to overloading. It also helps us to control the pollution caused by the overloaded vehicle. The owner of the vehicle can also track if there is any loss of goods during travelling.

Truck details can be shared with police for safety measurement and monitoring of truck. Placing an RFID tag when vehicle crosses check posts the load in truck can be shared with them which increases security to vehicle. The load in truck can be displayed along with its live location in google maps which is user friendly mobile application.

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