Design and development of automatic vehicle overload control system

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Abstract: Traffic accidents are on increase in Ethiopia and it has resulted into unattainable crisis on economic, social also vehicular aspects. From various causes of the accidents, overloading of the vehicle takes the lion allotment. Effects of the overloading of the vehicle encompasses human life will be in drastic danger, unimaginable injuries to the passengers and individual and government economic crisis. Besides service life of the vehicle will decrease and tires are more prone to wear, steering control becomes more difficult and vehicles takes longer to react to braking, decreased safety and driving comfort of the vehicle.

Firmly this bad practice has been seen in passenger and commercial vehicles. This research work focuses on commercial vehicles specifically on truck vehicles, because data shows that more percentage of overloading lay towards heavy vehicles.

This research work presents the overloading control and warning system by using load sensor which detects the weight of the vehicle. In case the weight is exceeding from the prescribed load, the audio and light warning system will activate to warn the driver. Further, the overload command is sent to the fuel system to shutoff the engine. Thus, the vehicle is not allowed to move unless the load comes under prescribed limits. The over load warning will give the tremendous advantage towards safety and reduce the loss of human life and economic crisis.

Finding the deflection of the leaf spring then by using potentiometer converting the deflection value into voltage in ten iteration is conducted. The voltage gap was examined and the first gap is normal load the second gap is warning and the last gap is fuel shutoff stage. Modelling the system in the MATLAB was conducted by setting the governing equations. Here the result show that the output is linear because the governing equations are linear. Thus, it implies the system is effective. In the MATLAB modelling load versus deflection and deflection versus voltage shows how the system works and the result shows it is linear result. Finally, by using protous software the system work has been shown.

Key words**: Overloading, control and warning, protous software, voltage gap, fuel shutoff.**

I. Introduction

Controlling the overloading vehicle system start in 19th century which is Traditional weight limit enforcement procedures are static weighing. This was the only method approved by the legal metrology up until the mid-1990s.Weighbridges, and wheel and axle scales, are used to measure gross vehicle weight and wheel or axle loads. If axle scales are used, the gross vehicle weight is obtained by summing the individual axle loads. If wheel scales are used, an axle load is obtained by summing the wheel loads of the same axle. [3]

For any business, maximizing efficiency is key reducing operating costs and improving profit margins. When transporting goods, the temptation to overload a vehicle in a bid to maximize to pay load and reduce fuel cost can be a costly mistake. [2]

Overloading of a commercial draft vehicle causes stress on vital components of the vehicle, such as drive trains, brakes, springs, tires, and the like, which are beyond the design tolerances of these parts. As a result,

overloading of a vehicle may seriously shorten the working life span of the vehicle and result in higher replacement costs to the vehicle operator. An overload commercial vehicle may also comprise a threat to the public safety when operated on the highways, due to its reduced ability to brake from high speeds or to negotiate corners and the like.

An overloaded truck is more likely to be involved in an accident, and have more severe consequences, than a legally loaded truck. Vehicle overloading control is a challenging task from its planning to operation and management because it has to be addressed a number of issues of the different disciplines such as legal provisions, electronic system, computer system, mechanical system, traffic signaling system, facility management, human resource management, financing, operation of weighbridges, and maintenance management.[2]

This has given motivation to the research team to design and develop an overload warning and control system, which can sense the load automatically and prohibit the drivers and user of the vehicle to put excessive load permissible limits.

II. Problem statement

Overloading the vehicles is one of the major cause of traffic accidents. Now a days these bad and dangerous practice losses the human life and individual as well as countries affluence. Although these practice increase rapidly time to time because of many reason it is unable to control efficiently.

The vehicle will be less stable, difficult to steer and take longer to stop. Vehicles react differently when the maximum weights which they are designed to carry are exceeded. Overloaded vehicles can cause the tire to overheat and wear rapidly which increases the chance of premature, dangerous and expensive failure or blow-outs. The driver's control and operating space in the overloaded vehicle is diminished, escalating the chances for an accident. The overloaded vehicle cannot accelerate as normal – making it difficult to overtake At night, the headlights of an overloaded vehicle will tilt up, blinding oncoming drivers to possible debris or obstructions on the roadway Brakes have to work harder due to 'the riding of brakes' and because the vehicle is heavier due to overloading. Brakes overheat and lose their effectiveness to stop the car.

The existing systems that used to control the overload of the vehicle have vital problems, basically the effectiveness problem that means the way of controlling the overload is only warning not stop the vehicle. Besides some of the system work in pavement of the road and vehicle will weighing under the circumstance of the station. This controlling method have drawbacks like require human power,

Staff is needed to select and intercept trucks in the traffic flow, to perform the weighing operation on the static control area, and to fine the violators and apply other penalties as needed. And It is difficult to safely perform checks on heavily trafficked highways and motorways. With high traffic volume, and the increase on roads of heavy vehicles, static weighing becomes ineffective and acts as a limited deterrent. Require long time required for static weighing, when several trucks are selected for checking. The other thing is not efficient.

III. Objectives

A. Main objective

To design and development of vehicle automatic overload control system

B. Specific objective

- To identify various alternatives design for vehicle automatic overload control system
- Design and development of warning system for automatic vehicle overload control system (ISUZU NPR400)
- To Design and development of fuel cut-off system for an automatic vehicle overload control system
- Mathematical modelling of the system.
- Validate the results using various soft wares.

IV. Significance

This research concern about preventing the vehicle from overloading .This method is secure and feasible and it gives effective

controlling system of the vehicle for overloading. Thus, it will safeguard the human life and economic crises.

The implication of this research is to encounter the vehicle stability, to save the components of the vehicles via reducing the chance of failure due to overloading. In addition to this, it will prevent the vehicle from unexpected and unnecessary catastrophic failure. Besides that, the main problem which is the fatigue of government officials specifically traffic police will decrease.

The social and economic crises of the countries also decrease. The road and bridges also kept in working condition for a long period of life without damages and cracks. It increases the driver comfort besides the goods will deliver safely to the society in fact it can eliminate both social and economic crises. This system is significant to save and secure the individual and country's economic and avoid wastage due to accidents.

V. Literature review

Controlling the vehicle overloading methods start in 19th century by announcing static weighing which is traditional enforcement practices. This was the only method approved by the legal metrology up until the mid-1990s. Weighbridges, and wheel and axle scales, are used to measure gross vehicle weight and wheel or axle loads. If axle scales are used, the gross vehicle weight is obtained by summing the individual axle loads. If wheel scales are used, an axle load is obtained by summing the wheel loads of the same axle. [5]

The concept of WIM is using wheel or axle scales, mainly equipped with load cells – the most accurate technology – and installed in concrete or strong asphalt platforms of at least 30 to 40 m in length. The software of the data acquisition and processing system is designed to analyze the signal of the load cells, taking into account the speed, and to accurately calculate the wheel or axle loads. It is a fully automated weighing system and can record all vehicles — whatever their speed, number of axles, or time of the day . [5]

Weight in motion (WIM) overload vehicle detection system {Source: Low Speed WIM using load cell wheel scales in a concrete platform (Châlon s/Saône, France).}

[17] Study on vehicle mounted overloading control system. In this paper automatic control system based on microcontroller for overloading passenger vehicle was designed. The system software was designed in assembly language. Its function is to determine whether a passenger was on the bus or off the bus according to the sequence of low signals received from the sensors.

[14] Intelligent load distribution system. The present invention relates to a system for optimizing load distribution on a tractor/trailer or other vehicle. A computer or other evaluation unit reads the information from at least one load Sensor, measuring the load and its distribution. The computer then evaluates the information with a database compiling information on optimizing load distribution for vehicle performance as well as for compliance with State and federal law.

[23] Truck Overloading Monitoring System Based on Beidou Vehicle Network System. Compass vehicle networking based on real-time monitoring system overloaded trucks, vehicle dynamic load measurement information compatible with Beidou vehicle terminal network overloading of goods vehicles to achieve real-time monitoring, can solve the truck overloading, speeding and other issues, and by the six-axis gyroscope measurements and ground vehicles the angled measuring the weight allowed to solve the problem when the truck downhill; measured with trucks during each vibration cycle time to solve the problem are not allowed to truck operation.

[10] Axle load control system and wheel base adjustment system. The control processor is arranged to continuously compare said actual axle load values with said predefined maximum allowable axle load

value for each axle, and to a driver indicate the need to control the wheel Suspension system in the described manner, said indication being communicated to the driver via a driver interface means provided with manual control means for effecting said individual adjustment of the Suspension characteristics for each axle in predefined discrete steps.

The other systems studied by different researchers are as given below:

Vehicle load warning system [12]

Vehicle overload sensor [15]

Vehicle load monitoring system [3]

Design of vehicle overload detection system based on geophone [19[

Weight overload warning system [24]

Design of Overload Vehicle Monitoring and Response System based on DSP[22]

An Intelligent Freight Corridor Overload Control System [6]

VI. Literature gaps.

To sum up in these literature review section different research's, journals, papers was assessed .in order to find the gabs those literatures categorized in three groups as per their work.

The first category is obviously the traditional way of controlling the overloading which is static weighing system.

The second category is weighing in motion system (WIM) which is weighing the vehicle in motion most scholars do these system in different way on the asphalt.

The third category is controlling the overload by establishing different system in in the vehicle itself by using new technology such as camera detecting system, sensors and processors giving warning to the derivers.

Category one gaps: Staff to check the over loading.

Category Two gaps: Accuracy

Category three gaps: driver is warned by the system. But driver may avoid warning.

VI. Material and method.

6.1The functional requirements of the system.

(a) The system should be vehicle mounted.

(b) No indulgence of staff required. The system should automatically control the overloading.

(c) the driver should not be able to avoid the warning.

(d) the vehicle should not be able to move till load is under prescribed limit.

(e) the system should be accurate.

6.2 System architecture.

As shown in fig, the system consists of Arduino system which is used to control the sensor and actuators. Here sensor give the input voltage to the Arduino then it will examine the voltage then give the command as per the voltage. If the voltage is low no warning will done and become medium it gives command to the buzzer and light to warn and if the load is become over the voltage becomes high so the Arduino system give command to the shut off solenoid to stop the fuel the engine. Unable to run unless the load is removed

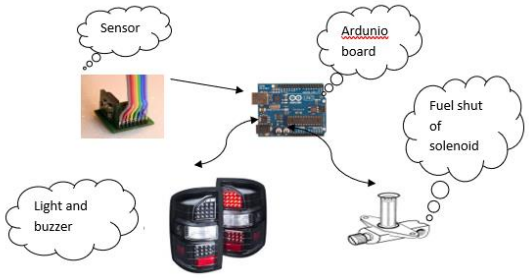

Fig. 2 Architecture of overload vehicle control system

6.3 Composition and working principle of the system

In order to control overloading of the vehicle, an automatic control system based on Arduino system for overloading commercial vehicle was designed in this paper. The system hardware is mainly composed of the sensor circuit, sensor working control circuit, fuel injection control circuit and other components. Sensor circuit mainly consists of processing

circuit. The sensor working control circuit is used to control the sensors by deflection of the spring. The front-end detection system has sensors mounted on both sides of the spring The system starts at the time when the load is over the limit load sensor detects and gives the measurement

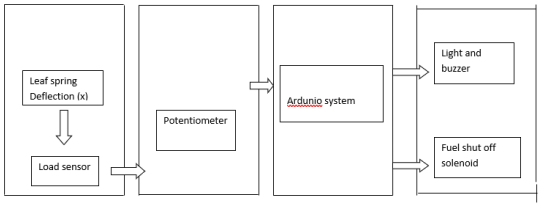

Fig. 3 block diagram of the control system

6.4 Concept Design

When the load is over then the nominal load, the deflection will occur and sign will be displayed on the dashboard for the driver. When the vehicle is over loaded the load cell in the suspension system will send the command to the controller. The shut off solenoid will be activated by the message from the controller and it will lock up. At this time no fuel will transfer to fuel injection pump

unless the overload is removed.

Fig. 3 concept design

(Due to limitations of the length of research paper the complete mathematical model is not given here.}

6.4 Design of the system by using MATLAB software

- **Setting the load as a variable and finding the deflection**

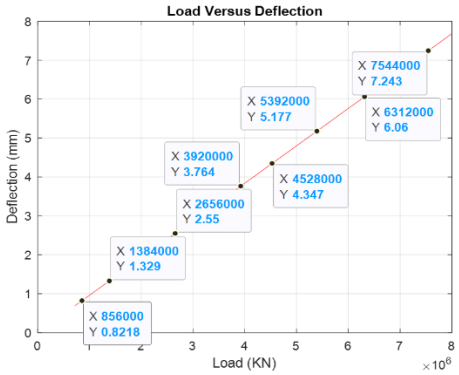

Fig. 3 load versus deflection graph

As we can see from figure 3 the load versus deflection graph when the load is increased the deflection increases spontaneously. Since the governing equation is linear the result became linear so setting gaps in deflection will encounter the response.

- **Setting the deflection as variable and finding the voltage**

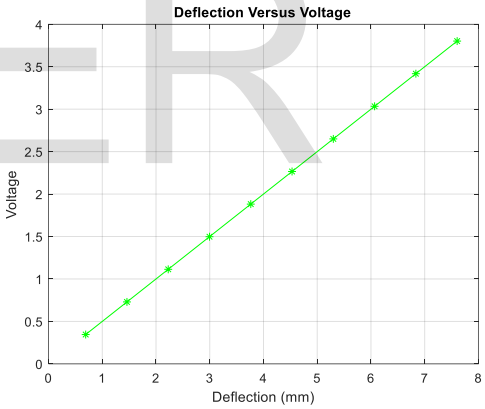

Fig. 4 deflection versus voltage graph

Here as we can see from fig 4 from deflection 0-3mm the voltage gap is 0-2v this is normal load, from 4-6mm the voltage gab is 2-3 this is warning area the light and buzzer will activate finally from deflection 6-8mm the voltage gab is 3-4v here depending on the situation the fuel will stop unless the overload is removed.

- **Design of the system by using protous software**

Using the range of potentiometer that convert the deflection value to the voltage taken as an input to the Arduino board and within these

values according to the range give the command to the buzzer and light so as to increase the weight the voltage will increase and the Arduino give the command to shutoff solenoid to stop the vehicle.

the limit switch protect the load sensor in which if the person remove the load sensor the limit switch will open and can't close again like the meter of electricity power which is available in our house. The supply voltage is come from the battery of the vehicle.

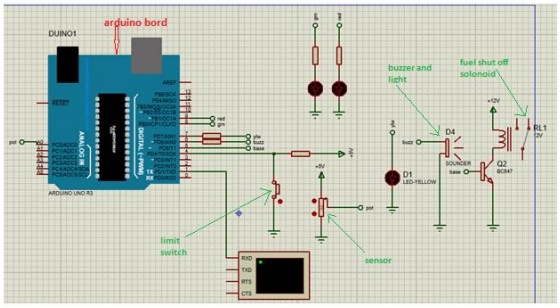

Fig. 5 architecture of the system by using protous software

VII. Result and discussion

Total weight (KN)	Deflection (Δx) in mm	Voltage (V)	action
720	0.651	0.6654	Normal load
856	0.8218	1.03	Normal load
1384	1.329	1.865	Normal load
2656	2.55	1.9567	Normal load
3920	3.764	2.013	Overload warning
4528	4.347	2.456	Overload warning
5392	5.177	2.678	Overload warning
6312	6.06	3.325	Cut off fuel supply
7544	7.243	3.67	Cut off fuel supply
8000	7.63	4.013	Cut off fuel supply

To Begin with from table above the result show that within the voltage gab trying to activate the system as per command. designing the leaf spring was the first task to get the deflection value so using Isuzu NPR 400 manual specification getting the deflection values by varying the loads.

Here the result shows that the deflection is minimum and by using potentiometer changing the values of deflection to voltage was conducted. Here the total supply voltage is 5V that is from the source of the vehicle battery. As the result show the voltage

Is not above the supply voltage. This show that not much power is consumption from the vehicle battery.

From load 720KN-2656 KN it is permissible load the voltage gap is from 0-2V in these voltage gab the driver can drive it normal.

From load 3920KN to 5392KN warning stage that means the light and the buzzer (audio) warning will activate when it reach the voltage gap between 2V to 3Vit warn to the driver to stop and eliminate overloaded .

Finally from load 6312KN to 8000KN the shut off solenoid will activate in the range of 3V to 5Vand it will closed so no fuel will transmit hence the vehicle will stop unless the overload is removed.

VIII. Conclusion

In this paper, based on the potentiometer load sensor detecting the load and giving the warning by sound and light finally by cutoff the fuel and stop the vehicle, a new type of vehicle overload detection system is

established, which make it possible to detect the overloaded vehicle and transfer the relevant data to the Arduino processor after the deflection of the leaf spring signal is obtained.

Then further processing can be done. The system has advantages of small size, high sensitivity, and it can adapt to different test environments. Relevant system tests showed that overloaded vehicles can be accurately detected by this system, which has a very good practical prospect.

This research basically used the MATLAB software in order to model the system, finding the deflection of the spring and convert to the voltage by potentiometer besides protous software is used to show how the system work.

In these system by voltage gab warn the driver by light and sound to reduce the overload if not the voltage will increase as per the load increase the full will stop any place. The challenge in this system was how to secure the system so limit switch is installed so the transport minister must check in every time.

IX. Recommendation

The responsibility to implement this system lay on all the stockholders mainly the transport minister. The system should be implemented at the national level to decrease the traffic accidents which are caused by the overload of the vehicle. Besides the automotive engineers must collaborate with software and electrical engineers to implement the system in the ground. Last but not the least in order to save our life and huge damage of resource which is caused by the traffic accidents one way which is overload all peoples must protect the system.

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