International Research Journal of Innovations in Engineering and Technology (IRJIET)

ISSN (online): 2581-3048

Volume 8, Issue 3, pp 141-145, March-2024

https://doi.org/10.47001/IRJIET/2024.803018

A Review on Real Time Rollover Safety System for Heavy Duty Vehicle

[1]Shahanediwan Tanjil, [2]Prof. A.P.Kinge, [3]Prof. Dr. S.G.Kanade

[1]Student, M.E. Electrical Engineering (Power System), TSSM's BSCOER, Pune, Maharashtra, India

[2,3]Asst. Professor, M.E. Electrical Engineering (Power System), TSSM's BSCOER, Pune, Maharashtra, India

***Abstract* - In today's modern era, automation plays a pivotal role in various inventions. This paper specifically addresses the crucial aspect of ensuring the safety of loaded vehicles, particularly from potential risks like rollover, side wind impact, and overturn incidents. While current methods employ trailer tracking through GPS and collision mitigation technologies, these approaches have certain limitations. To overcome these limitations and enhance performance and reliability, this paper proposes a novel system leveraging the stm32f407 microcontroller, servo valve, and hydraulic system.**

Keywords: Real Time, Rollover Safety System, Heavy Duty Vehicle, Automation, overturn incidents.

I. INTRODUCTION

Nowadays, accidents involving heavily loaded trucks are a big problem worldwide. These accidents mostly happen because of crosswinds, which can cause the truck to overturn or roll over. Furniture trucks and trucks carrying containers are especially at risk from crosswinds. Also, keep in mind that as your vehicle moves, it creates its own wind. The faster you drive, the stronger this wind becomes. Sometimes, this wind is strong enough to knock over motorcyclists or push other vehicles around so much that the driver can't control them.

Secondly, when a vehicle is heavy, it tends to keep moving straight ahead even if the driver tries to turn it. This happens because the weight of the vehicle makes it want to stay in its current direction. When the driver does turn the steering wheel, the weight of the vehicle shifts to the outside of the turn. If the driver doesn't slow down, this can cause the vehicle to tip over or slide out of control. Nowadays, there's been an increase in truck accidents due to these factors.

II. PROBLEM STATEMENT

Category wise distribution of accident and fatalities by road users during the year 2021 presented in Chart 1 reveals two wheelers accounted for 40.7 percent of total accident deaths on National Highways followed by cars, taxis, Vans & LMVs (16.4%), pedestrians (16.9%), Trucks of (8.9%), Buses (2.5%) and bicycles (3%).

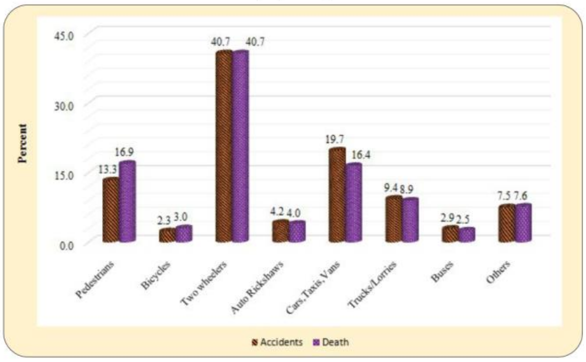

Figure 1: Road user category wise distribution of Accidents and Fatalities during 2021 (in percent)

4 Most Common Reasons for Heavy Truck Accidents:

1) Large Load Hazards

Heavy trucks like ballast tractors and heavy haulers are designed to carry large amounts of cargo at a time, but even these vehicles have their limits. Heavy and very heavy trucks can be overloaded unsafely, presenting serious hazards for other vehicles on the road. When a load is not secure, or there is too much cargo loaded onto a flatbed truck, that cargo may fall off and present obstacles for other vehicles that are driving at high speeds. This is particularly dangerous when the truck is carrying hazardous materials, like harmful chemicals or metal. Sometimes, overloading is the result of a trucking company putting profits over safety. Other times, it is the result of a driver's haste and negligence in the loading process.

In some cases, an improperly loaded truck may have a load shift during travel, upsetting the centre of gravity and tipping the truck over. Because of the unbalanced load, it is extra important to keep the trailer lights and safety equipment operational. Additionally, a truck with an uncoupled trailer, which offsets the vehicle's balance, will make the chance of tip-over greater. It is important to remember that as the vehicle becomes heavier, the longer the stopping distance needed.

2) Weight & Height Limitations

The sheer weight of a heavy truck can make the vehicle unable to travel on certain highways and bridges that cannot

International Research Journal of Innovations in Engineering and Technology (IRJIET)

ISSN (online): 2581-3048

Volume 8, Issue 3, pp 141-145, March-2024

https://doi.org/10.47001/IRJIET/2024.803018

handle them. Many trucks are also too high to go under certain bridges and overpasses. For this reason, all their routes must be pre-approved by the Department of Transportation. When truck drivers run into unforeseen travel obstacles, disaster can occur.

3) Dangerous Driving Conditions

In many states, very heavy trucks need pilot cars to guide them, and in most states they are not allowed to travel at night. Considering that large trucks are already high-weight and hard to stop and control, driving with an over-sized load in risky weather conditions exponentially increases the risk of an accident. Indeed, slippery roads or reduced visibility can force a truck to maneuver or stop quickly, and the results can be disastrous. The threat of insecure driving conditions is magnified when the truck driver is fatigued from long distance driving.

4) Driver Error

About 87% of fatal and injury crashes are caused by the truck's driver. 32% of heavy truck crashes occur because the truck runs out of the travel lane; 29% occur because of vehicle loss of control (traveling too fast, cargo shift, vehicle system failure, poor road conditions); and 22% occur because of a collision with the rear end of another vehicle in the truck's travel lane.

III. SYSTEM DESIGN

The centre of gravity changes depending on how something is moving. If the centre of gravity is higher, it means the object is less stable. So, the stability of an object is linked to where its centre of gravity is. It's important to put the load in the right place along the length of a truck to prevent the wheels from locking up when you brake.

There are two types of centre of gravity. The first one, called longitudinal centre of gravity, depends on how wide and tall something is. The second one, called transverse centre of gravity, depends on how long and wide the truck is. The system is set up to keep the transverse centre of gravity within a safe range. When a truck overturns, the centre of gravity of the load shifts to the left or right, depending on which way the truck is tipping. This causes the vehicle to roll over.

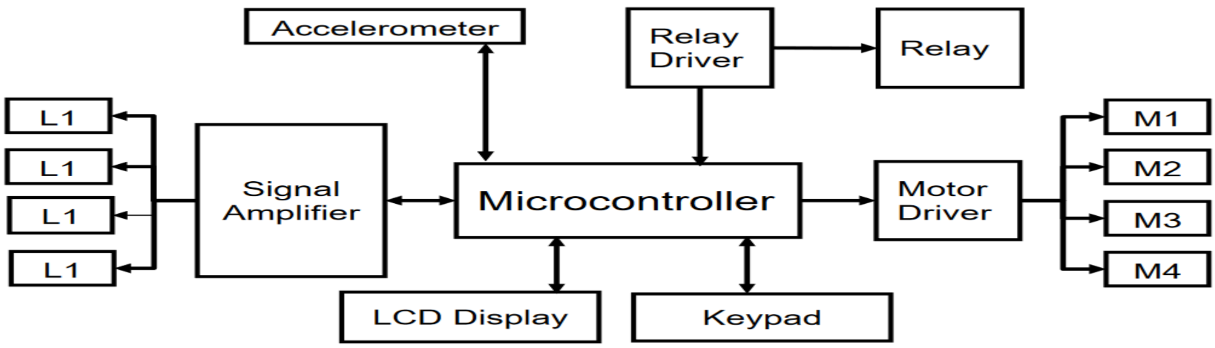

Figure 2: Block Diagram

3.1 Load cell: A load cell is a part of a safety system used in heavy vehicles to check how much weight or load the vehicle is carrying. It's like a sensor that measures the force or pressure exerted on it by the load. This information helps ensure that the vehicle isn't overloaded, which could affect its stability and safety on the road. If the load cell detects too much weight, it can alert the driver or the vehicle's system to take action, like adjusting the load or stopping to prevent any safety risks. So basically, the load cell helps keep heavy vehicles safe by monitoring and managing their load.

3.2 Signal Amplifier: Load cells are sensors that measure the weight or load on the vehicle. They detect changes in load distribution, which could indicate potential instability or an impending rollover situation. The signals from the load cells are usually small and need to be amplified to ensure accurate detection. The signal amplifier boosts these weak signals to a level that can be effectively processed by the microcontroller.

3.3 Microcontroller: The microcontroller receives amplified signals from the signal amplifier, which are indicative of the vehicle's load distribution and potential instability. Data Processing: The microcontroller processes the incoming data in real-time, utilizing algorithms to analyse the vehicle's dynamics and determine if there are any indications of a potential rollover or loss of stability.

3.4 Relay Control: Based on the analysis of the incoming data, the microcontroller may issue commands to relays or relay drivers. Relays are electromechanical switches that can open or close circuits, while relay drivers are used to control the operation of relays. These relays may be responsible for

International Research Journal of Innovations in Engineering and Technology (IRJIET)

ISSN (online): 2581-3048

Volume 8, Issue 3, pp 141-145, March-2024

https://doi.org/10.47001/IRJIET/2024.803018

activating various safety mechanisms, such as deploying stabilizing devices or adjusting suspension systems, to help prevent a rollover.

3.5 Servo Motor (M1-M4): In addition to relay control, the microcontroller may also command a servo motor. Servo motors are used to actuate mechanical systems with precision. In the context of a rollover safety system, a servo motor could be employed to adjust steering or braking mechanisms in response to detected instability, helping to regain control of the vehicle.

3.6 Accelerometer Integration: The microcontroller also interfaces with an accelerometer, which measures the vehicle's acceleration and tilt angles. This accelerometer data provides additional inputs for the microcontroller's analysis of the vehicle's dynamics and stability.

3.7 Bidirectional LCD: The bidirectional LCD display is capable of showing information both to the user and receiving input from the user. It provides real-time feedback and alerts regarding the vehicle's stability status, rollover risks, and any detected abnormalities. The microcontroller controls what information is displayed on the LCD based on its analysis of the data from various sensors, including load cells and accelerometers. Additionally, the LCD may prompt the user for input or display instructions in case of emergency situations.

3.8 Keypad: The keypad is used as an input interface for the user to interact with the Real-Time Rollover Safety System. It allows the user; typically the vehicle operator or maintenance personnel, to input commands, configure system settings, acknowledge alerts, or initiate emergency procedures. The microcontroller reads the input from the keypad and responds accordingly, adjusting system parameters or activating specific safety features as required.

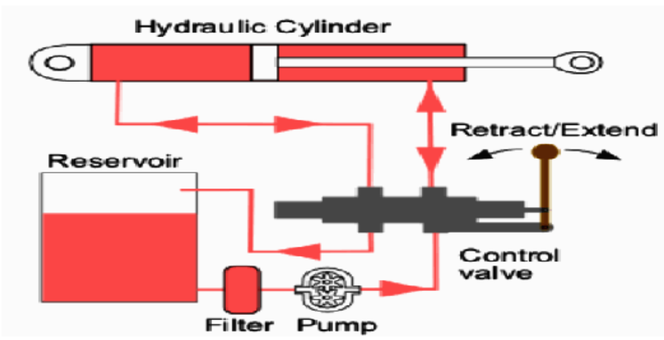

Figure 3: Hydraulic System

3.9 Hydraulic System Working: These are devices that convert hydraulic energy into mechanical energy to perform work. In this case, the hydraulic actuators would be responsible for moving the trolley within the container. Hydraulic Fluid: The system would use hydraulic fluid, usually oil, as the medium for transferring energy. This fluid is pressurized and then directed to the hydraulic actuators to initiate movement. Pumps: Hydraulic pumps are used to pressurize the hydraulic fluid. These pumps can be electrically or mechanically driven and are responsible for creating the pressure required for moving the trolley. Valves: Valves control the direction and flow of the hydraulic fluid. Directional control valves would be used to direct the fluid to the desired actuator, while flow control valves regulate the speed of the actuator's movement. Control System: A control system would manage the operation of the hydraulic system. This could involve manual controls operated by the vehicle operator or automated controls that respond to inputs from sensors monitoring the trolley's position or the vehicle's stability. The hydraulic system for trolley shifting would be integrated into the broader rollover safety system for the heavy-duty vehicle. This integration would ensure that the movement of the trolley is coordinated with other safety measures to enhance overall vehicle stability and safety, particularly during maneuvers or in emergency situations where rollover risk is increased.

IV. CALCULATIONS

4.1 Tilting Method

Type 1: Tilt around transverse axis of the vehicle

This is one of the common method used to determine the CG in an automobile.[1] From this method CG values can be obtained in two steps. In the first step longitudinal direction of CG position can be determined by using static equilibrium equations (see Figure 4) using the reaction weights measured beneath the 4 tyres of the vehicle with the help of a weighing platform. Using the same reaction weights, transverse direction of CG can also be determined.

In the second step, in order to determine the vertical height position of the CG, the vehicle should be lifted to a certain height above the ground level (either front or rear of the vehicle) and the 2 reaction weights from 2 of the weighing platforms are noted down again.

Following values have to be measured in this experiment: wheelbase, weights on scales and height into which vehicle is lifted (see Figure 4). (Rektorik, 2017).

The calculations used to determine CG are presented below. [1]

Step 1- Calculating CGx:

Vehicle wheel base = L
Mass of front left wheel = m1

International Research Journal of Innovations in Engineering and Technology (IRJIET)

ISSN (online): 2581-3048

Volume 8, Issue 3, pp 141-145, March-2024

https://doi.org/10.47001/IRJIET/2024.803018

Mass of front right wheel = m2
Mass of back left wheel = m3
Mass of back right wheel = m4
Mass in front= m1 + m2 = mf
Mass in back= m3 + m4 = mr
Mass of vehicle = MV = = mf + mr

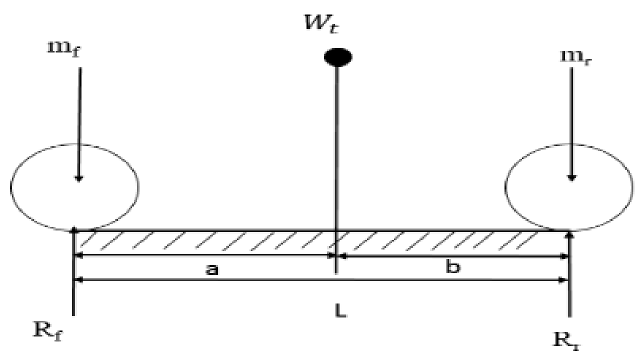

Figure 4: Test object on a leveled surface

One can express the forces acting under each axle and the weight of the vehicle as follows:

Rf = mf *g = (m1 + m2)*g
Rr = mr *g = (m3 + m4)*g
Wt = MV*g= (mf + mr)*g

Type 2: The longitudinal position axis of the vehicle

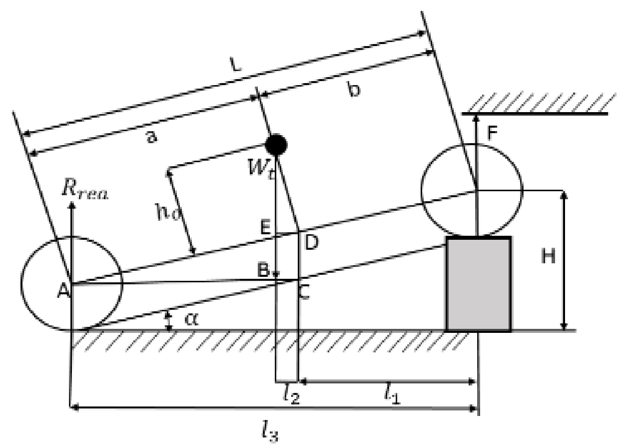

Figure 5: Test the object lifted to a certain height source

The longitudinal position of the centre of gravity of the vehicle is then determined from the following two equilibrium moment equations relating either to rear or front axle.[1]

Wt * b = mf * L
Wt * a = mr * L

By simplifying the above equations one can get the longitudinal CG values as follows:

From rear end,

b = (m1 + m2)∗L/m1 + m2+m3 + m4

From front end,

a = (m3 + m4)∗L/ m1 + m2+m3 + m4

Calculations involved to determine the value of CGY is similar to the above calculations except that the moments are taken on the loads on the other 2 wheels.

Step 2- Height above the ground CGZ:

From the figure 5, one can represent the distances as follows:

Rear distance l1 = b*cosα, l2 = ho*sinα and l3 = L*cosα.

Then the equation of static torque equilibrium relative to the rear axle axis has the form:

Rrea* l3 = Wt *(l1 + l2)

Rrea = Wt ∗(l1 + l2)/l3

Rrea = Wt ∗(b∗cosα + ho∗sinα)/ L∗cosα

After further simplifying the above equation CGz (ho) can be written as follows:

$$\{ho = (Rrea*L/\,Wt - - b)/\tan\alpha\}$$

V. CONCLUSION

"Maintain centre of gravity trolley and make truck safety," a might emphasize the importance of maintaining a stable centre of gravity in trolleys and trucks to enhance safety. It could discuss how implementing measures to ensure proper weight distribution and balance in these vehicles can significantly reduce the risk of accidents, including rollovers and loss of control incidents. The effectiveness of technologies or systems used to monitor and adjust the centre of gravity in real-time, thereby improving the stability and safety of trolleys and trucks during operation.

REFERENCES

[1] Design of Station for Calculating Centre of Gravity of Truck Cabin Supervisor at Linköping University: Marcus Eriksson Supervisors at Scania CV AB: Conny Elmbro & Martin Kjellman.

[2] Model Based Estimation of Height Center of Gravity in Heav Vehicles Model Based Estimation of Height DELEER BARAZANJI Master of Science Thesis, Stockholm, Sweden 2012.

ISSN (online): 2581-3048
Volume 8, Issue 3, pp 141-145, March-2024
https://doi.org/10.47001/IRJIET/2024.803018

[3] Rollover risk prediction of heavy vehicle using high order sliding mode observer: experimental results H. Imine, A. Benallegue, T. Madani and S. Srair.

[4] P. Milliken and J. de Pont, “The Effect of Cross-Sectional Geometry on Heavy Vehicle Performance and Safety” Transfund New Zealand Research Report No. 263.

[5] R. W. Allen, H. T. Szostak, D. H. Klyde, T. J. Rosenthal and K. J. Owens, ”Vehicle dynamic stability and rollover”, technical report, Systems Technology, Inc, NHTSA 263, Hawthorne, CA U.S.-D.O.T., NHTSA, USA, 1992.

[6] H. Imine, A. Benallegue, T. Madani and S. Srairi, ”Rollover risk prediction of an instrumented heavy vehicle using high order sliding mode observer”, ICRA’09, IEEE International Conference on Robotics and Automation, pp. 523-527, May 12-17, 2009, Kobe, Japan.

[7] T. D. Gillespie and S. M. Karamihas, “Characterising trucks for dynamic load prediction”, Int. J. Vehicle Design, Vol. 1, No. 1,pp. 3-19, 1993.

[8] H. Imine, L. Fridman and T. Madani, “Steering Control for Rollover Avoidance of Heavy Vehicles”, IEEE Transaction on Vehicular Technology, Vol. 61, No. 8.

AUTHORS BIOGRAPHY

Tanjil Shahanediwan,
Student, M.E. Electrical Engineering (Power System), TSSM's BSCOEROER, Pune, Maharashtra, India.

Prof. A.P.Kinge,
Asst. Professor, M.E. Electrical Engineering (Power System), TSSM's BSCOER, Pune, Maharashtra, India.

Prof. Dr. S.G.Kanade,
Asst. Professor, M.E. Electrical Engineering (Power System), TSSM's BSCOER, Pune, Maharashtra, India.

Citation of this Article:

Shahanediwan Tanjil, Prof. A.P.Kinge, Prof. Dr. S.G.Kanade, “A Review on Real Time Rollover Safety System for Heavy Duty Vehicle” Published in *International Research Journal of Innovations in Engineering and Technology - IRJIET*, Volume 8, Issue 3, pp 141-145, March 2024. Article DOI https://doi.org/10.47001/IRJIET/2024.803018

****