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A Novel Approach Development of Electrically Assisted Braking System

Niresh J., Abdul Samath A.

***Abstract:** This paper provides the means to effectively improve the braking system using BLDC controlled by microcontroller. Efficiency of the conventional mechanical braking is drastically influenced by friction, because of this friction due to braking, life of the brake followed by integrity of the system became compromised. To overcome this, normal braking is assisted using BLDC. Prototype is developed, and the parameters such as braking distance and braking time for various vehicle speed are measured and discussed.*

***Keywords:** Critical Speed, Arduino Board, IR Sensor and DC Motor*

I. INTRODUCTION

The main objective behind the development of the braking system is to retard the automobiles from motion with effective braking, reduced wear and fading away of brake pads and calipers and also with neglecting the lock of the wheels which occur during the normal mechanical braking system at the high speed of the automobile by using microcontroller which operates based on the wheel speed and other braking parameters and produces braking actuation in well controlled and desirable manner. G. Srinivasa Rao and G. Keseva Rao [1], Braking system controlled by microcontroller in Electric Hybrid vehicle. The embedded system programing developed in KEIL and PROTEUS software. The status indicated by means of LCD or LED.Xiaoling He and Jeffrey W. Hodgson [2], A model for the hybrid electric vehicle (HEV) powertrain simulation has been constructed with a specific power control strategy for an electric-assisted HEV in parallel configuration. The model is implementation based on empirical formulation and power control strategy by means of throttle position. Incorporates Regeneration and regeneration braking for battery capacity recovery.Jeongmin Kim, Chiman Park, Sungho Hwang, Yoichi Hori [5], The control algorithm designed depend on yaw rate, slip ratio and lateral acceleration. The performance of control algorithm evacuated in MATLAB simulations. A tests car with two independent drive motor at rear wheel developed. BekheiraTabbache, Abdelaziz Kheloui, and Mohamed El HachemiBenbouzid[8], traction drive system for electric vehicles (EVs) with two separate induction motor drive-based wheels.

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The proposed traction drives use direct torque control and adaptive flux and speed observer-based algorithm. The digital signal processor TMS320LF2407 are carried out to show the effectiveness of the proposed adaptive ED in terms of robustness and stability.

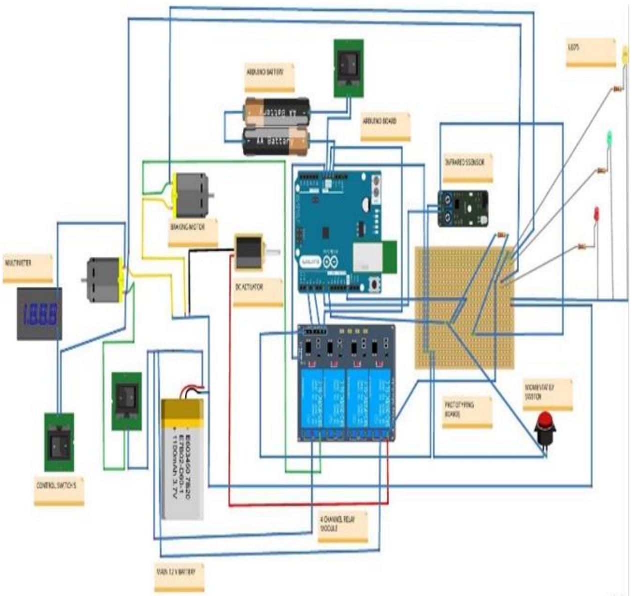

Fig.1 Circuit Diagram

Abdel fatah Nasri, Brahim Gasbaou and Mohammed Fayssal[10],The electric differential system ensure robust control behavior on the road, It also allow controlling and every driving wheel to turn at different speed in curve. Electric vehicle sliding mode control's simulated in MATLAB Simulink environment. The efficiency of proposed control comparing with classical PI controller with overshoot. AbdelfatahNasri,Abdeldjabar and Ismail Khali Bousserhane[9], The electronic differential system ensures the robust control of the vehicle behavior on the road. It also allows controlling, independently, every driving wheel to turn at different speeds in any curve. This paper presents the study of an hybrid Fuzzy-sliding mode control (SMC) strategy for the electric vehicle driving wheels, stability improvement, in which the fuzzy logic system replace the discontinuous control action of the classical SMC law. Our electric vehicle fuzzy-sliding mode control's simulated in MATLAB SIMULINK environment.

II. CONSTRUCTION

The wooden board of the frame is used to support the whole setup. The L-angle frame is mounted above the wooden board to support other prototype components.

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The prototype consistsof two different categories of dc motor, a driving motor for thesimulation of the engine and a braking motor for the simulation of the braking dc series motor. These two motors are supported by the L-shaped flange extended from the L-frame and these two motors are coupled to the shaft.

Fig.2 Proto

Two ball bearings which are welded to the frame is used to support the shaft and the disc, since the circular disc is permanently welded to the shaft. The circular disc is provided for the simulation of the brake rotors, which is held stop by the brake calipers in the real-time working system. A dc solenoid type actuator is C-clamped with L-angle frame, so that the actuation shaft will be normal to the circulardisc which is welded to the shaft for the convenience of the simulation of the mechanical type friction braking system. An IR speed sensor is placed parallel to the shaft in the frame to the side of the braking motor. The shaft is also fitted with the rotating metal element for the speed sensing, it is placed in a way so that the speed sensors led will be perpendicular to the metal element. Other electronic components like Arduino board, relay module, strip board, batteries, control switches, and other connecting wires are laid on the wooden board. Wiring of these components are given in the diagram (Fig.1).

III. WORKING

The dc driving motor is switched on. So, the shaft coupled to the driving motor also rotates. The IR sensor continuously reads the speed of the rotating shaft and transfers the corresponding rpm values to the Arduino board for the selection ofwhich braking system should be used. When the brakes are applied by using the control switch, Arduino will receive the signal by the control switch and decides which braking system should be used. The Arduino have two conditional control loops programmed, when the rpm of the shaft is higher than theparticular value the Arduino will automatically activates the dc braking motor through the relay module whose terminals are reversed so that the dc motor will try to rotate in a direction opposite to the rotation of the driving motor and shaft, which will decelerate the rotating shaft and decrease the rpm values to the efficient braking speed of the dc actuator. When the rpm of the shaft is lower the Arduino will directly activates the dc actuator. Since the dc braking motor is normally coupled to the shaft, the rotating shaft will rotate the braking motor, which will produce some electric current. It can be read from the multimeter and its flow can be controlled using a control switch. The strip board is soldered in a manner so that the red led will glow when the dc driving motor is switched on, the green led will glow when the braking motor is switched on and the yellow light will glow when the actuator is switched on.

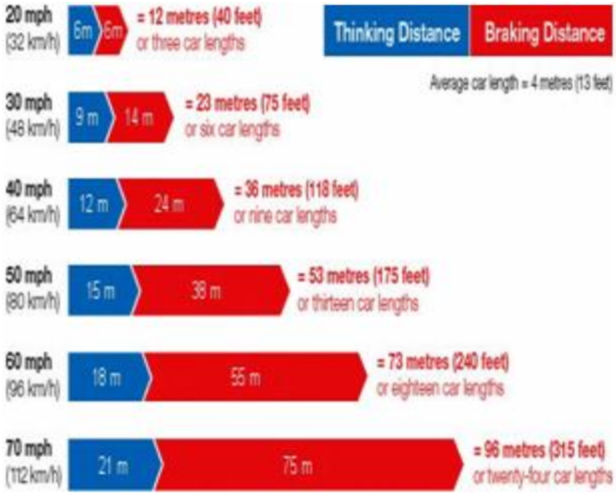

Fig. 3 Braking Distance Validation

IV. BRAKING DISTANCE

Braking distance refers to the distance a vehicle will travel from the point when its brakes are fully applied to when it comes to a complete stop. Hence the braking distance will be the important parameter. The various braking distance for the various speed of the car can be identified from the graph (Fig.4) The stopping distance include the distance travelled while the driver notices the hazard and applies the brakes (thinking distance), and the vehicle comes to a full stop from its initial speed (braking distance). The distance above are based on the average reaction of 0.67 seconds, which assumes the driver is alert, concentrating and not impaired. Driving when tired, distracted or impaired significantly increases the reaction times, so the thinking distance above should be regarded as minimum.

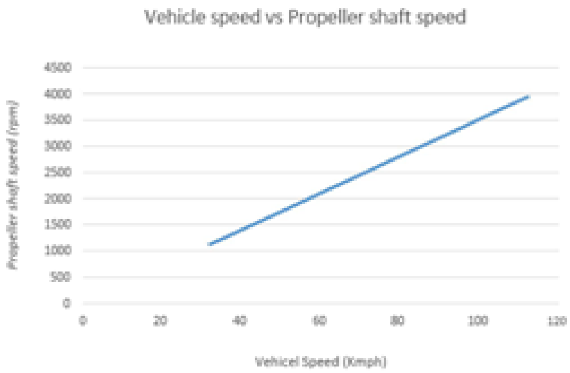

Fig.4 Speed and shaft

The braking distance depends on how fast the vehicle was travelling before the brakes were applied and is proportional to the square of the initial speed. That means even small increases in speed means significantly longer braking distances.

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Braking distances are much longer for larger and heavier vehicles, and in wet or dry conditions, so these figures are minimum. These stopping distance of cars are estimated by the government official's.

V. CALCULATIONS

A. Before Braking

Driving motor

N = 300 rpm

T = 0.2943Nm

P = 2πNT /60

P = (2π x 300 x 0.2943) / 60 = 9.245 w

For 80 kmph, the propeller shaft speed is 2820 rpm

In our prototype the speed of the driving motor is 300 rpm

2820 / 300 = 9.4

Then the speed is scaled by 9.4:1

B. After Braking

Braking motor

P = 2πNT / 60

P = 9.245 w, N = 1000 rpm

T = (P X 60) / (2πN)

T = (9.245 x 60) / (2π x 1000)

= 0.088Nm

If the vehicle is running at the speed of 80 kmph after braking the speed is reduced by 32kmph.For 32kmph, the propeller shaft speed is 1128rpm.

The speed of the braking motor is 120 rpm

1128/120.44 = 9.365 ≈ 9.4

Then the speed is scaled by 9.4:1

VI. RESULTS AND DISCUSSION

For the comparison of the normal mechanical braking and plugging used braking system can be done using some parameters like braking distance and the braking time. For the calculation of the braking time required for the normal mechanical braking system can be calculated as follow

For the 80 kmph speed of the vehicle,

The total braking distance = 53 m, with the steering inconvenience and the lock of wheels

Hence the total stopping/braking time = 2.385 s

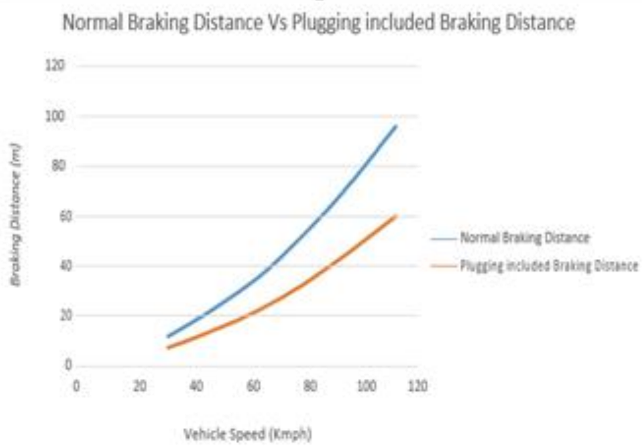

Fig.5 Comparison of Normal & Plugged Braking Distance

For the calculation of braking distance and time of the plugging type associated braking distance can be calculated from the braking time graph of the plugging type braking,By assuming 112 kmph speed as the 100% speed. Then the75% speed becomes 80 kmph. Because the propeller shaft rpm for 112 kmph as 3948 rpm, and the 2961 rpm will be the 75% of the 3948 rpm, whose corresponding vehicle speed will be80 kmph. For the 75% of the speed the braking time of the plugging type braking will be 0.5 s from the instant the brake has been applied.

The total braking time for plugging

Implemented braking system = (0.5 To + 10^{-6} To) + (12 m)

= (11.111 + 12)

= 33.11 m.

37.52% reduction of the braking distance by efficiently using the plugging typebraking with the mechanical braking system

The braking time is reduced from **2.385 s to 1.489 s**

37.57% reduction of the braking time by efficiently using the plugging type brakingwith the mechanical braking system.

For the given vehicle speeds

1) 32 kmph
2) 48 kmph
3) 64 kmph
4) 80 kmph
5) 96 kmph

The braking distance and the braking time can be plotted on the graph

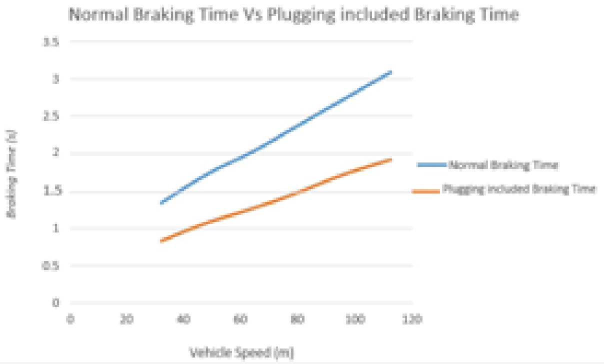

Fig. 6 Comparison of Normal & Plugged Braking Time

VII. CONCLUSION

We have successfully fabricated the prototype for the "BRAKINGSYSTEMWITH MICRO CONTROLLER" andthe design calculation for the respectivereal time system is also done. This new braking system, which we developed has many advantages than the normal mechanical braking system.

- It doubles the life span of the brake pads and calipers.
- Prevent the wheel and steering lock during braking at the high speeds.
- Reduces the braking distance and time.

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From the calculation we have done it is found that our new braking system will reduces the braking distance by **37.52%** and braking time by **37.57%**. These plugging included braking system are frictionless, noise free and there are no components to wear out and it also requires less maintenance.

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