Innovative application of Kinetics for Low-Cost Vehicle Speed Control System using Linear Cable and Open-Coil spring

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Abstract

While many state governments in India, like Tamilnadu, Karnataka, Punjab & Haryana, going for compulsory inclusion of speed controllers in vehicles, commercial speed controllers is priced between Rs 10000 to Rs. 20000, which imposes a financial burden to the vehicle owners. In the proposed system, by using economical elements like a microcontroller (Rs.250), a motor driving circuit (Rs.100), 12V motor with gearbox (Rs. 300), springs (Rs. 40) & other miscellaneous items (< Rs.180), in innovative manner the total amounts to Rs. 870. Incorporating other costs, the market price would be Rs. 3500, which is 65% to 80% less when compared to the present product's market price. It is achieved through replacing a rigid link between the linear cable and the cap of the carburettor/fuel-injector by a spring link whose stiffness is selected with respect to that of inside the carburettor/fuel-injector. So, when the current speed exceeds the desired speed, by compressing the spring link with the aid of a motor, the speed of the vehicle can be reduced/controlled without the need for the driver to change the throttle's position. Detailed force analysis along with a video proof shows the innovation behind this small modification. Thus when the proposed product, which can be easily incorporated & does not affect the engine's performance, is commercialized, after making some market ready alterations, will benefit the vehicle owners in large & also in successful implementation of the law.

Keywords: speed control, automobile speed control system, low-cost speed control system.

1 Introduction

1.1 First – what is the need for an innovation in automobile speed control system?

1,19,860 [1]– these many people die every year due to road accidents in India, with a substantial amount owing to over-speeding. As a preventive measure, many state governments in India (Karnataka Government – [2], Punjab And Haryana High Court [3], Tamilnadu Government [4],[5]) to fit speed controllers in all school and college vanes & buses. Though this rule is highly appreciable, with the commercial speed controller costs ranging from Rs. 10,000 to Rs. 20,000, it imposes considerable financial burden on middle-class vehicle owners. In a view to make all vehicle owners financially comfortable with speed controllers and thus making the law to be

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successfully implemented, an innovation is proposed and it is tested with successful outcome.

2 Existing Arrangement for Acceleration in Automobiles without Electronic Control Unit

The linear control cable used in automobiles consists of a steel wire which is enclosed by an inner cable A and an outer cable B. The length of the steel wire is greater than the length of cable A which is in turn greater than the length of cable B. One end of the steel wire is connected to the throttle & the other end to the carburetor's/Fuel-Injector's valve, such that the rotary motion at the former is converted into linear motion at the later, where it pushes a valve which moves while simultaneously compressing a spring on its other end so that when the throttle is released the valve returns back to its initial position.

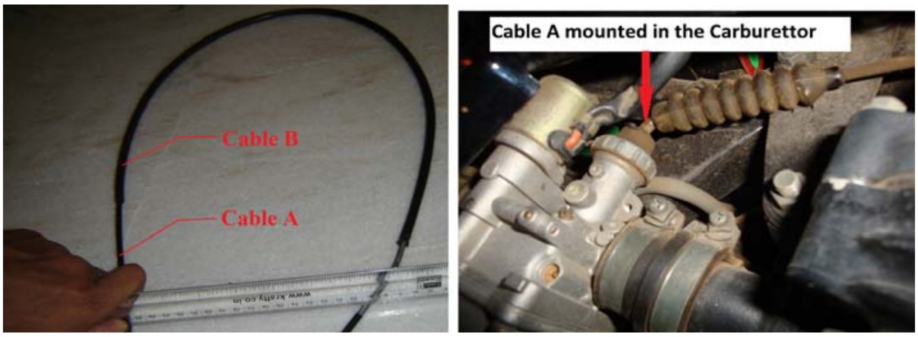

Figure 1: Typical view of a Linear Control Cable used in automobiles and it's mounting in the Carburetor/Fuel-Injector.

3 Proposed Innovative Mechanical Arrangement

In the proposed arrangement, a new spring, Spring B, is introduced along the linear cable as shown in the Fig. (3) & Fig. (2).The diameter of the hole (d1) in the Fig. (3) and the Cable B's outer diameter are such that, they arrest the axial movement of the spring B. This arrangement helps to transfer the reaction force for the force applied at the throttle for compressing the spring (Spring A) in the carburetor/fuel-injector, to be acted on the spring B instead of acting on the carburetor cap, as in upper part of Fig. (6). *This transfer of the reaction force is heart of the innovation*. A motor is fixed near the carburetor, as in right of Fig. (2), so that through a wire it can pull the steel wire of the linear cable towards the carburetor while simultaneously compressing the spring B. The desired force deflection characteristic of Spring A & B is shown in Fig. (4). The spring B's stiffness is at least 4 times the stiffness of the spring A.

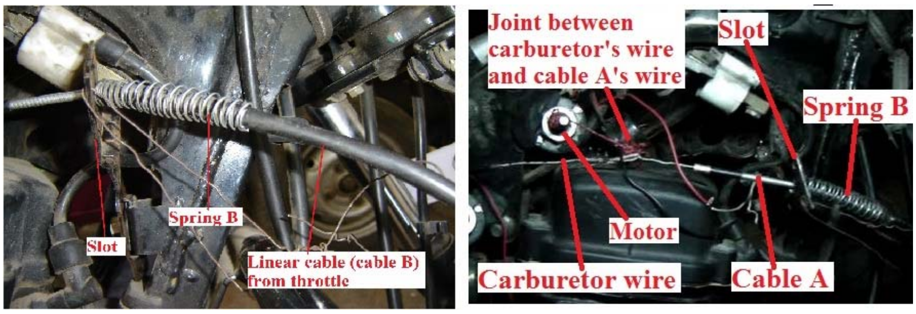

Figure 2: The rigid link being replaced by spring link near the carburetor and full view of the modifications near the carburetor (made by the author) which can be compared with Figure 1 for better understanding.

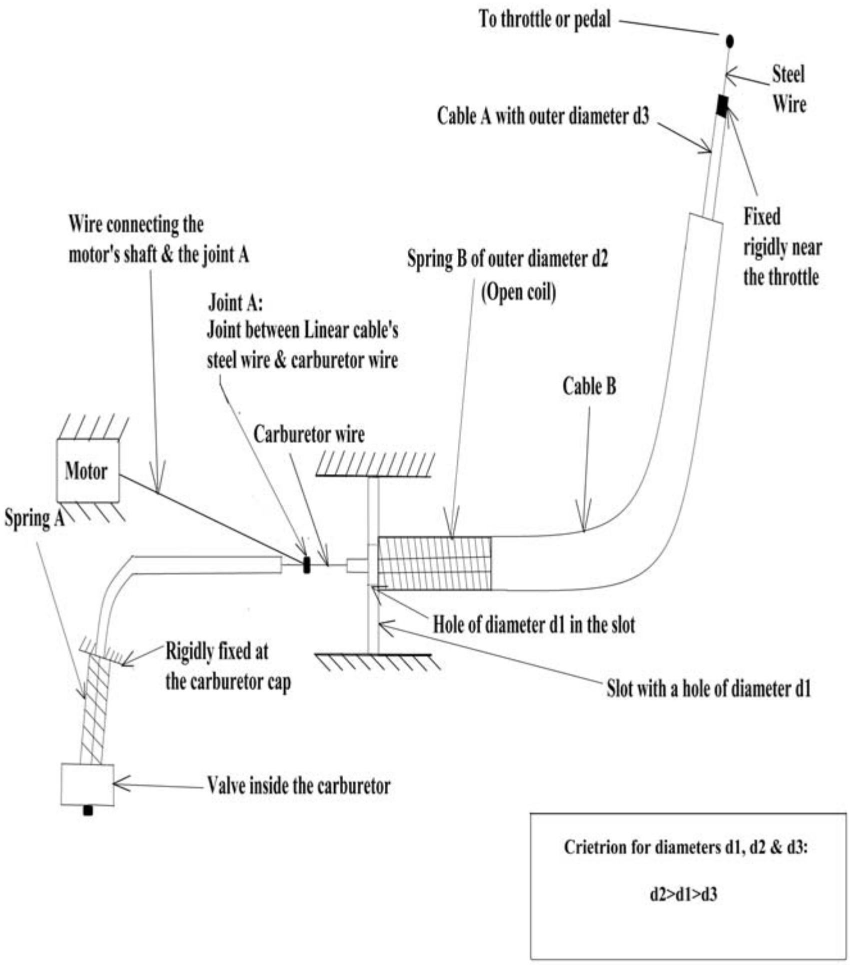

Figure 3: Proposed innovative arrangement for speed control.

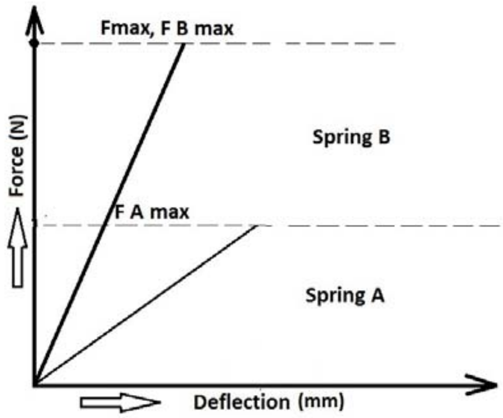

Figure 4: Desired force-deflection characteristic of the Spring A & B.

3.1 Arrangement of the micro-controller

A micro-controller is used (PIC 16F877A) to sense the current speed. In case of digital speedometer, the digital signal can be interfaced with this micro-controller or in case of analog speedometer, reed switch can be used along with a magnet. The micro-controller is connected to the 12V motor using a motor driver circuit, L293D. The motor driver circuit is used because of the inductive nature of the motor and voltage requirement of it. They are placed in well-ventilated area in the automobile.

4 Mechanism of Working of the Innovative Mechanical Arrangement

Now, with these arrangements we shall now witness the innovation behind this arrangement kinetically.

4.1 Force analysis

Now, if the driver rotates the throttle, the maximum force that he will be able to apply is F1 (see Fig. (6) upper part), which depends upon the stiffness of the spring A. Thus F1 = FR1. Since the steel wire is not and cannot be connected to the carburetor/fuel-injector in the shortest possible distance, when user applies the force F1, the steel wire will exert the same force F1 on the body of the linear cable, so as to form a straight line between the two ends, and this will in turn be acting on the mechanical slot through the spring B, i.e. Spring B will exert the force F1 on the mechanical slot and the reaction force FR1 will be acting on the spring B by the mechanical slot. As the stiffness of the spring A is less than the spring B’s stiffness, the force FR1 acting on the spring B will compress it much less than the compression of the spring A. This is how the forces will be acting under normal conditions, i.e. when actual speed of the vehicle is less than or equal to the desired speed of the vehicle.

4.2 The innovation

Consider the shortest length between the throttle and the carburetor is q, as in Fig. (5) Now, when the current speed of the vehicle exceeds the desired speed, the micro-controller will signal the motor to run for a particular number of milliseconds, depending upon the current speed, so that the motor will rotate and through the steel wire the wire in the control cable is pulled towards the carburetor/fuel-injector and thus the speed of the vehicle is reduced. But, all this happens without the driver changing his throttle position and the speed can be controlled by the micro-controller, even when the driver rotates the throttle further. This is possible by the innovative mechanical arrangement which is explained below.

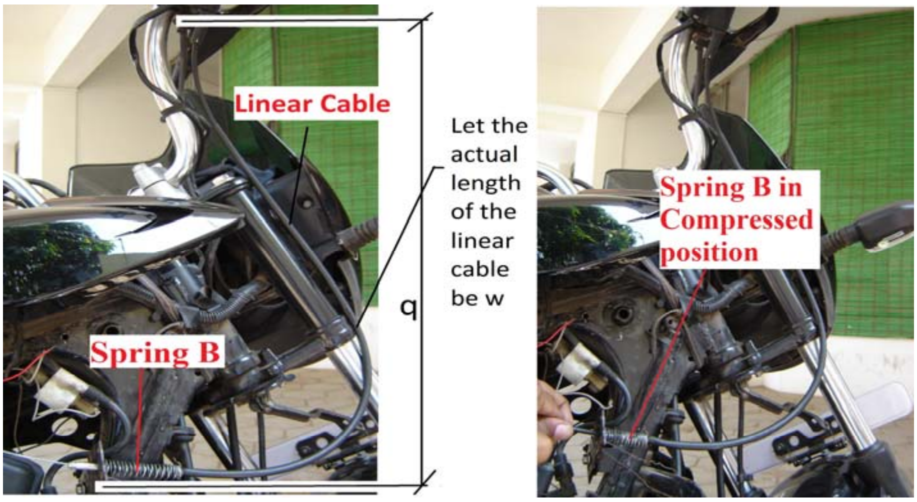

Figure 5: The two photos explaining the main concept of the innovation (done by the author).

4.3 How does the innovation work?

When the motor pulls the steel wire towards the carburetor, the spring B compresses and due to which the length w, reduces equivalently. This reduction in the length, say dw, is the length of the steel wire that will be available for pull by the motor. This can be better understood by viewing the Fig. (5) carefully. In both the figures, everything remains same except, the spring B is not compressed, in left side while spring B is compressed in the right side, due to which the length of the wire available beyond the slot is increased equivalently to compression of spring B. Thus the motor is able to control the speed, without the driver changing his throttle position. Now *even if the driver rotates the throttle further, all his applied force will be isolated, i.e., will go in compressing the spring B. This is because the motor has sufficient torque (say, 12 Newton centimetre) & the stiffness & length of the spring B is selected such that the maximum force required for complete compression is less than 12 N, so that whatever be the applied force the motor would not be a victim of it and* *thus it will not rotate in the reverse direction, but transfers the force to be acted upon the spring B by the slot and thus the position of the steel wire near the carburetor is not affected* and thus the speed is fully, for the time being, controlled by the motor.

5 Force Analysis to Understand How the Innovation Works

Let F2 (see Fig. (6) lower part) be the force with which the motor pulls the cable towards the carburetor end so that the speed will be reduced. Now because of the selection of the stiffness of the spring A and spring B, the reaction force FR1 due to the user force F1, will compress the spring B only, before the force F1 exceeds F2 maximum and thus no force will be acting on the spring A. Thus the motor will completely control the maximum speed of the vehicle. Thus whatever be the force F1 being applied by the driver, all of this force goes in compressing the Spring B only. Thus the user will be psychologically satisfied, as the throttle/pedal will be rotated/ pushed but actually the maximum speed is only controlled by the motor. The micro-controller is suitably programmed to rotate the motor at appropriate time and also to rotate in reverse direction so that control can be switched back to the user. Additional features like variable speed limits for day and night time or varied speed limits within the city and outside it can be suitably programmed with additions like Global Positioning System (GPS).

6 Cost-Estimation

The elements of the innovation are a microcontroller (Rs.250), a motor driving circuit (Rs.100), 12V motor with gearbox (Rs. 300), springs (Rs. 40) & other miscellaneous items like wires, slots… (< Rs.180), & total amounts to Rs. 870. Incorporating other costs like transportation, dealer's commission…, and the market price would be Rs. 3500, *which is 65% to 80% less when compared to the present product's market price.*

7 Existing Design

To the best of the author's knowledge, there are 3 major ways adopted in the existing design. One is to have a mechanical limit to the movement of the throttle, so that it cannot go beyond a particular distance. But this method limits the engine's power, when the vehicle is below the set speed limit. Another way is to have a flow-control valve in the fuel supply line, so as to limit the fuel supply when required. But this method is costly. Another way is to have a force feedback in the throttle, which is also a costlier option.

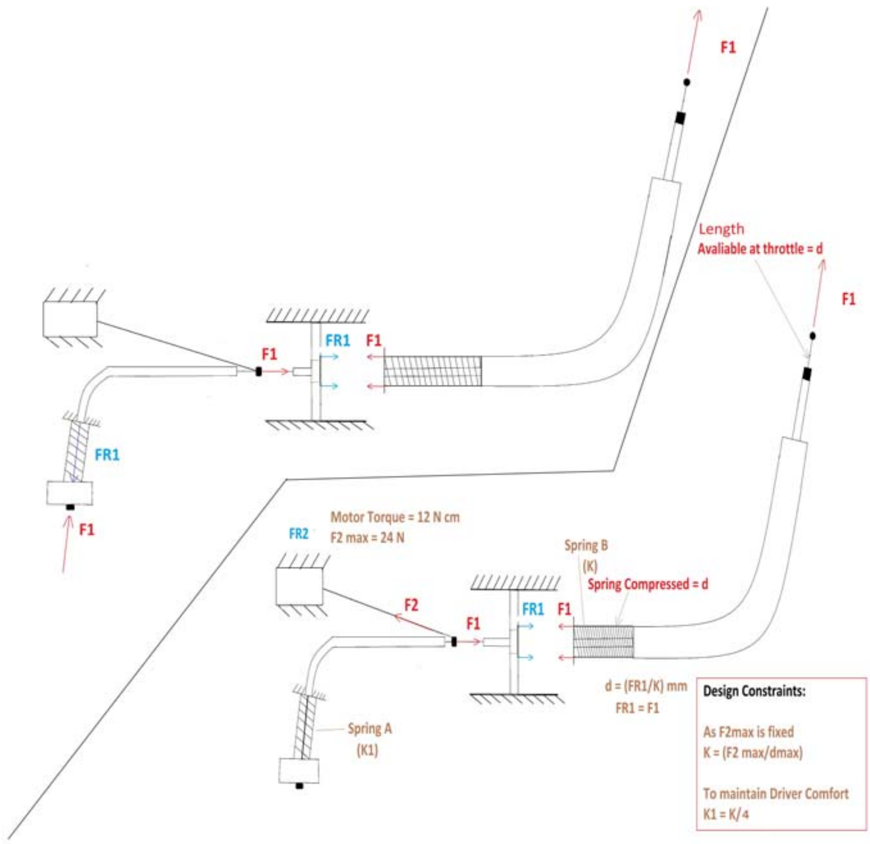

Figure 6: Upper part- Force analysis of the innovative mechanical arrangement when actual speed of the vehicle is <= to the desired speed & Lower part- Force analysis when the motor is actuated i.e. when current speed of the vehicle exceeds the desired speed of the vehicle.

8 Advantages of the Proposed Innovation

The proposed innovative system can be used in any automobile that uses linear-cable for acceleration. Economical. 65% to 80% price reduction when compared with present market price. None of the engine's critical component is altered and thus inclusion of this device in an automobile, does not affect the engine performance. Full engine power can utilized as long as the automobile is within the desired speed. Fast (5 seconds) & smooth control over the speed of the vehicle, see Fig. (7). *Driver need not worry about the throttle position to go at desired speed, i.e., even if he gives full throttle, the automobile will go only at desired speed.* No high skill is required for installation. Can be installed within 4 hours, using only simple tools. As only simple mechanical items are used, the system has high reliability of mechanical items.

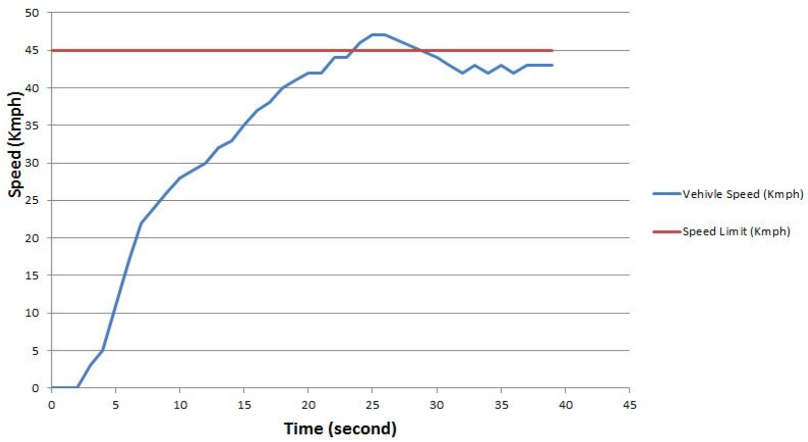

Figure 7: Performance Graph of the proposed system.

9 Disadvantages

In case of automobiles with Electronic Control Units (ECU), this system has no role to play, as it can be programmed in the ECU itself.

10 Conclusion

Thus the innovation, which costs only 20% to 35% of the current market price, when commercialized after making some market-ready alterations, will definitely ease the financial burden for the vehicle owners & aid in successful implementation of the law & thus does its part in saving precious human life from accidents due to over-speeding. The mechanical arrangement has been tested by the author himself, by fitting it into his bike, which is working reliably for the past 1 year.

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