Recent Advances and Emerging Technologies in Commercial Vehicles: A Review

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Abstract

Commercial vehicles are most widely used in transportation of goods and passengers and are revolutionary in the supply chain management. There are wide range of technologies that have been adopted by the companies which are manufacturing commercial vehicles over the past few decades. From manual steering to the power steering, diesel engine to electric powered vehicles, normal braking system to ABS braking system, such technologies have emerged and have gained prominence in the aspects of enhanced performance, reliability, comfort and in maintaining standards. Commercial vehicles have been developed in such a way that vehicles can be driven without human beings with the advent of technology. But still, there are lot of challenges that hinder the developments of commercial vehicles. Commercial vehicles are expected to grow much more rapidly in the coming years, because of the trending technologies such as electric powered vehicles, autonomous vehicles etc., This article reports on a comprehensive review of various advanced technologies in commercial vehicles, their advantages and disadvantages, applications, the challenges that are existing and finally, scope for future development of the commercial vehicles.

Keywords:
Automotive technology, Commercial Vehicles, Steering system, S Technology, Hybrid Systems, PEM Fuel Cells, Pneumatic Braking System

1. Introduction

Development of commercial vehicles differ from that of the light vehicles. For light vehicles, initial cost is the basic criteria. But as far as the commercial vehicles are concerned, payback period is the major concern. It will be generally four years in most of the cases. In some cases, it could be of two years also. Another major parameter is the cost per kilometer. Some of the technologies which improved the performance and emission characteristics of commercial vehicles are discussed here.

1. Use of Exhaust Gas Energy

Use of exhaust gas recirculation systems, increasing the valve overlap period, use of selective catalytic reduction methods improved the control of exhaust and catalyst temperatures. These methods proved beneficial in terms of performance and improving the emission standards. Waste heat recovery systems are one of the promising technologies which can improve the performance of the commercial vehicles. Technologies which can use ranking steam cycle has the potential to regain the exhaust heat and convert it into mechanical work. Tata motors is one of the leading commercial vehicle manufacturer, which is using EGR and SCR effectively. Alternatively, shaft generators can be used in highways, where much traffic will not be there, as the shaft generators produce electricity with constant speeds. Preferential trips are used for tripping the auxiliary devices like a/c compressors can be tripped when not required or there is a huge load on the vehicle and much power is required from the engine.

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2. Steering System

Different types of steering systems are being used in the vehicles. Steering systems are ranging from manual steering to hydraulic power steering. Now-a-days, much sophisticated steering systems which have potential for electrification and provide reduction in fuel consumption are available in commercial vehicles. Integrating systems networking of the vehicle steering system and of the dash board controls, assist the driver to have better control on lane changing, hand on wheel detection, traffic jam assistance etc. They reduce the strain on drivers, and also improve the safety of the drivers. Linking systems and intelligent steering systems enhance the automatic steering capabilities and provide much comfortable ride for longer drives. Some of the steering systems used in the commercial vehicles mentioned in the literature are mentioned below. Gyoungyun Lee [1] described the construction process of the power steering system with EHPS and Motor driven electric control actuator. Before this technology most of the commercial vehicles use Electric Powered Steering System using the electric power. This technology has reported that it is expected to improve fuel efficiency by about 1% and it can be an alternative for application to electric and hydrogen fuel cell vehicle. Krogh and Thorpe [2] carried out an experiment using Path Relaxation by adding a grid search Method with some obstacles, Algorithm is used to move Autonomously to the destination using Dynamic Steering Control and critical points are noted on grid plot. Marino et al. [3] carried out an experiment using Gyroscope, Vision System and PID Control System to perform path following in the case of roads with an uncertain curvature and the proposed control law is successfully tested by experiments using a Peugeot 307 prototype vehicle. Nguyen et al. [4] Performed an experiment to keep automatic lane under multiple system constraints, namely actuator saturation of the steering system, roads with unknown curvature and uncertain lateral wind force and reported that the resulting non-parallel distributed compensation controller is able to handle not only various system constraints but also a large variation range of vehicle speed. Borrelli et al. [5] carried out an experiment to stabilize a vehicle along a desired path while fulfilling its physical constraint using Model Predictive Control (MPC) and reported that complex steering manoeuvres are relatively easily obtained as a result of the MPC feedback policy, leading to the capability of stabilizing a vehicle with a speed up to 17 m/s.

3. Transmission:

Dual clutch transmission systems are being found more suitable in heavy trucks, as they can avoid the losses in the acceleration work. They also contribute to fuel savings and improve acceleration. Now-a-days, CVT's are gaining more prominence than the automatic transmission systems, as provide a smoother driving experience when comparing it to a traditional automatic. Some of the advancements in the transmission systems have been mentioned below. Soleimani et al. [6] had examined the world's automotive and emerging technologies situation, the status of commercial vehicles and s technology model based on external models, technical specifications, and cost and found out that the technology of the studied heavy-duty vehicles (Titan) is close to the time of his fall, because spending puberty, so, according to the investigation of new technologies. Dieter et al. [7] conducted an experiment to reduce the fuel consumption in vehicles using Rankin cycle which converts into mechanical energy and found out that the most favourable solutions are a piston machine with water or ethanol as working fluid or a turbine with ethanol as working fluid. Matulic et al. [8] conducted an experiment to reduce the fuel consumption in heavy vehicle by auxiliary load power from internal combustion engine to PEM fuel cell and analysed the vehicle on different road conditions of pollutant emission and fuel consumption and found that this experiment could give around 9% fuel savings. Cho-Yu et al. [9] conducted an experiment by designing an air hybrid technology, Regen EBD through which kinetic energy is converted into pneumatic energy of compressed air which

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has several applications to use in commercial vehicles and found out that the Regen EBD has managed to improve the fuel savings to 6.5% - 7.2%.

4. Braking System

With the advent of new technologies, conventional braking systems become obsolete in the commercial vehicles. Current day braking systems are aiming at electrification of all drives, improvement of the personnel safety and overall efficiency of the vehicle. Key components to be considered for braking systems are reliability and safety. Conventional braking systems cannot offer zero drag. Torque vectoring is one of the key area for braking systems. Reduction of activation time is also a key feature. By fitting the brake boosters, this can be achieved. Regenerative braking systems with generator/motor combinations is one of the trending technology, which is gaining prominence. Technologies which do not require conventional energy to drive them like vacuum braking should be developed in a much better manner to improve the performance of braking systems. Electro-mechanical braking systems also have to be developed. In this context, Continental has come up with wedge braking system. Some of the developments in the braking systems have been discussed below. Karthikeyan et al. [10] conducted an experiment by using electro-pneumatic braking system instead regular braking system in commercial vehicles and analysed and compared by various runs and found that the predictions of the model agreed well with the experimental data. Bowlin et al. [11] conducted an experiment using control scheme braking system for regulating the pressure of air in a braking chamber of a braking system. The control scheme regulates the pressure in the brake chamber by modulating the displacement of the treadle valve plunger and found that the test run carried tracks realistic desired pressure trajectories. Subhajit and shankar [12] conducted an experiment using model-based control scheme ABS system which prevent locking of wheels by regulating the brake chamber pressure and found out that the experiment studies the system is able to follow the desired brake chamber pressure with an actuation delay, which is inherent to the typical pneumatic brake system of a heavy commercial vehicle.

5. Sensor Integration

Integrating sensors in the Commercial Vehicles as been rapidly increasing with rise in influencing of safety and emission control Regulations imposed by various organizations. Parameters such as Pressure, Temperature, position, Motion, Micro-Electro-Mechanical Systems (MEMS), Image and Level and so on Highlights the Driving Safety with much Accuracy with rising in Technologies. Some of the developments in the Sensor Intergration have been discussed below. László and Ansgar. [13] analysed and reviews the usage of “Intelligent chassis system” which electronically control the operation of the chassis subsystems and co-ordinate their operation on a higher level and concludes that the electronically controlled systems are key in advancements of commercial vehicles and plays a major role in implementation of Autonomous Commercial Vehicles. Abel et al. [14] generated a model Functional mock-up Interfaces (FMI). The coupling via FMI for Model Exchange was achieved for control modules from MATLAB/Simulink into the SimulationX powertrain model and secondly from the 1D-multiphysics powertrain in simulationX in multibody vehicle in SIMPACK and reported that the FMI technology has clearly shown its capability to be applied in the productive simulation process. Ottorino et al. [15] developed a model – ZEBRA battery-based propulsion system which is designed to power a specific urban unit within the category of electric commercial vehicles and performance analysis carried out with reference to the real behavior of both the whole propulsion system and each main component, when powering the commercial vehicle. The dynamic analysis, performed on different road slopes, has shown that the considered ZEBRA battery pack is able to supply sufficient electric power to follow the dynamic constrains required by a typical urban driving cycle, with a guaranteed autonomy of about 85

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km on a plane road and almost 45 km on the maximum road slope of 5%. Ioannis et al. [16] presents a new class of ranging sensors and a new class of fuel brake controllers which eliminate or bypass many of the limitations, and can be used in all stages of ITS deployment and reported that these range of sensors have given satisfies results when carryout the experiments. Hansen et al. [17] considers and review recent advances of In-vehicle human-machine systems for route navigation and reported that the presented advanced approaches are effective at increasing the performance of human-machine interaction systems such as speech/speaker recognition in adverse real-life in-vehicle environments. Chai et al. [18] reviews the recent progress and development of technologies in vehicle monitoring system for accident prevention and concludes the key challenges faced due to the sensors and how it could be developed. Juan et al. [19] reviews the drivelines in all-electric vehicles (EVs) and compares by taking the survey of the electric motors used in commercial EVs is presented and illustrates those comparisons between the different motors are difficult by the large number of parameters and the lack of a recommended test scheme.

6. Suspension System

The suspension system plays a critical role in the dynamics of an automobile and active force actuators in the suspension can result in improved dynamics, be it ride comfort, better road holding or reduced body roll. Recent Technologies such as development for an electronically controlled pneumatic actuator that can be used in suspensions of commercial vehicles such as trucks, tractors-trailers and buses. The tasks of suspensions of vehicles are contractionary and the prevailing problems cannot be readily solved by the use of adaptive suspension systems. However, varying the properties and characteristics of suspension systems in respect to the different loads transported by a commercial vehicle, to vehicle speeds and to dynamic manoeuvres, nearly present as good results as closed loop controlled adaptive suspension systems do. Some of the developments in the Suspension System have been discussed below. Cecchel and Ferrario [20] developed a technically reliable and cost effective safety component for Light Commercial Vehicles (LCVs) in aluminium alloy and carried out experiment through technical and economic study of some different light weighting solution and selection of the best case and reported that a proper component resistance has been achieved by the selection of a primary AlSi9MgMn alloy and by the substitution of the traditional high pressure die casting plane or “U” shape with a completely hollow structure obtained through the addition of sliders for the total length of the component.

7. Environmental Concerns

Global evidence shows that exposure to diesel pollution causes lung cancer, heart disease and a range of other metabolic and respiratory diseases. Black carbon from diesel vehicles also traps 16 times more heat and is a more serious warming agent than carbon dioxide. Heavy-duty trucks have been the slowest in reducing and improving their emissions as emissions standards are not uniform across the country. This is mainly because of the current practice of keeping emissions standards tighter only in a few cities and lax in the rest of the country. While all major cities have enforced Bharat Stage IV (BS-IV) emissions standards, trucks continue to get registered at Bharat Stage III (BS-III) level outside these cities. The vehicle industry has not ramped up the production of BS-IV trucks adequately as there is barely any demand. This problem will only be corrected only in 2017 when the BS-IV emissions standards are implemented nation-wide. Some of the developments in the Environmental Issues have been discussed below. Abhishek. [21] reviews on transition for automakers based on technical understanding are discussed and challenges for the oil refineries to provide low-sulphur fuel throughout the nation within specified time is also mentioned. Manufacturing Heavy-duty vehicles based on BS-VI norms is the major issue for the OEMs is addressed and illustrates that there are lot areas which need to change to completely change to BS-

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VI vehicles. Troy et al. [22] reviewed to study the Environmental impacts of hybrid and electric vehicles (EV) address the full life cycle of these technologies and results of studies are synthesized to compare the global warming potential (GWP) of different EV and internal combustion engine vehicle (ICEV) options and reported that Details pertaining to key vehicle components such as the battery or drivetrain are even less documented. GWP is the most frequently reported result followed by acidification (SO2, NOx), smog (CH4, NMVOC, NOx), and toxicity impacts and the most important next steps toward understanding the impacts of EVs relative to ICEVs are improving our estimates of the impacts associated with the electricity used to charge a growing EV fleet. Pavlos and Ron [23] examined the contribution of trucking to the spatial distribution of mobile emissions in urban areas by using integrated urban land use and transport model (IMULATE) and estimated the differential traffic volume, due to the presence of commercial trips, in all the links of the transport network. These estimates are then translated into emissions of carbon monoxide (CO), nitrogen oxides (NOx), hydrocarbons (HC) and particulates and they reported that the presence of trucks is shown to produce a dramatic increase in particulate matter emissions as well. The analysis indicates that this increase is mainly due to combustion exhaust emissions from trucks, as opposed to tire and break wear. Overall, a 4.4% increase in vehicle miles travelled because of the presence of trucks can produce a 111% increase in PM emissions. For all pollutants, link level changes tend to be focussed along trucking routes. Krishna [24] shows the conversion of diesel engine to a CNG engine with little modifications using gas injectors, three-way catalytic converter to keep the output power, torque and emissions of compressed natural gas engines comparable to their gasoline or diesel counterparts and reported that on average the reduction of CO, CO2 and HC emission are 20-98%, 8-20%, and 40-87% respectively by CNG, as compared to the existing Cummins diesel engine. Natural Gas (CNG) represents almost a 50% savings over petroleum products such as gasoline and diesel fuel.

Futures and Challenges

The challenge for the commercial vehicle market is one of scale – because it represents a far smaller number of assets than the passenger car market, it has always played ‘second fiddle’ to its larger market cousin, often borrowing solutions and technology developed for that market. This has left the market fragmented, ill-served and not maximizing its potential. Every commercial vehicle OEM and most suppliers have their own, proprietary telematics offering. In addition, there is a wide array of aftermarket telematics solutions and third-party software vendors offering apps and platforms for data management. For fleet operators, particularly those with a mix of vehicle brand and age, there is an overwhelming choice of telematics solutions that often don’t integrate well with each other (if at all). Furthermore, solutions are typically ‘paid for’ and fleets are ill-equipped to be able to fund more than one or two business tools.

Ideally, Interact Analysis believes the industry would benefit from a period of consolidation in the commercial vehicle telematics market with a focus on developing a handful of global platforms that provide simple access to high quality solutions, whilst facilitating easy payment options. This would expand the value of telematics to fleet operators and truly allow the market to reach its maximum potential. The industry is Rapidly Increasing the integrating of new technologies with Recent Advancements. The industry is adopting new technologies in its operations at an unprecedented scale. In addition to technologies such as artificial intelligence (AI) and big data & analytics that have been around for a while, newer technologies such as the internet of things (IoT) and blockchain also find numerous applications in automotive.

Conclusions

Rapid changes are happening in commercial vehicle market. The advent of new types of Power trains, vigorous progress in autonomous driving technology has been pushing the expectations of buyers as well as general public. Analyst predicted

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that by 2030 these developments will have fundamentally transformed the market. It is suggested that the adoption rate of new power trains and autonomous vehicles will be vary by region and use. Companies like Volvo has introduced new way of driving named as “Power Steering with External Steering System” where driver can get out and drive the vehicle in situation where he needs assistance. Many Autonomous Vehicles has been tested to transport goods without a driver and has been successful. Not only these, but also commercial vehicles are working on dedicated track on the road with live electric supply for Electric Commercial Vehicles. Such improvements in the Commercial vehicles in practical could be more promising to the driver for his intense safety and ease in driving and controlling the vehicles in turn reduces the number of accidents around the world. Electric commercial vehicles can be introduced for short distances, where charging facilities are possible. Electrical commercial vehicles can also be used as linking transports.

References

[1] Youngyun Lee, Development of Hybrid Power Steering System for Commercial Vehicles, SAE Technical Paper, 2019.

[2] Bruce PI. Krogh, Charles E. Thorpe, Integrated Path Planning and Dynamic Steering Control for Autonomous Vehicles, Institute of Electrical and Electronics Engineers, 1986, 2(86), 1664-1669.

[3] Riccardo Marino, Stefano Scalzi, Mariana Netto, Nested PID steering control for lane keeping in Autonomous vehicles, International Federation of Automatic Control, 2011, 19, 1459-1467.

[4] Anh-Tu Nguyen, Chouki Sentouh, Jean-Christophe Popieul, Fuzzy Steering Control for Autonomous Vehicles under Actuator Saturation, Journal of the Franklin Institute, 2017, 355(18), 9374-9395.

[5] F. Borrelli, P. Falcone, T. Keviczky, J. Asgari, D. Hrovat, MPC-based approach to active steering For autonomous vehicle systems, International Journal Vehicle Autonomous Systems, 2005, 3, 265-291.

[6] Gholamhossein Soleimani, Magsod Amiri, Seyed Mohammadali Khatami, Using S Technology in the Automotive Industry with the Approach of Its Implementation in Commercial Vehicles, Industrial Engineering & Management Systems, 2016, 15(4), 290-297.

[7] Dieter Seher, Thomas Lengenfelder, Jürgen Gerhardt, Nadja Eisenmenger, Michael Hackner, Ilona Krinn Robert Bosch GmbH, Waste Heat Recovery for Commercial Vehicles with a Rankine Process, 21st Aachen Colloquium Automobile and Engine Technology, 2012, 1-15

[8] N. Matulic, G. Radica, F. Barbir, S. Nizetic, Commercial vehicle auxiliary loads powered by PEM Fuel cell, International Journal of Hydrogen Energy, 2019, 44(20), 10082-10090.

[9] Cho-Yu Lee, Hua Zhao, Tom Ma, Analysis of a novel mild air hybrid engine technology, RegenEBD, for buses and commercial vehicles, international Journal of Engine Research, 2012, 13(3) 274–286.

[10] P. Karthikeyan, Ch. Siva Chaitanya, N. Jagga Raju, S.C. Subramanian, Modelling an electropneumatic brake system for commercial vehicles, IET Electrical Systems in Transportation, 2011, 1(1), 41-48.

[11] C.L. Bowlin, S.C. Subramanian, S. Darbha and K.R. Rajagopal, Pressure control scheme for air brakes in commercial vehicles, IEE Proc. Intell. Transp. Syst, 2006, 153(1), 21-32.

 DOI : 10.36893.DRSR.2021.V08I14.157-163

[12] Subhajit Mahanty and Shankar C. Subramanian, A non-linear model-based slip controller for electropneumatic brakes in heavy commercial vehicle, International Journal of Heavy Vehicle Systems, 2013, 20(1), 35-60.

[13] László Palkovics, Ansgar Fries, Intelligent Electronic Systems in Commercial Vehicles for Enhanced Traffic Safety, Vehicle System Dynamics: International Journal of Vehicle Mechanics and Mobility, 2001, 35(4-5), 227-289.

[14] Andreas Abel, Torsten Blochwitz, Alexander Eichberger, Peter Hamann, Udo Rein, Functional Mock-up Interface in Mechatronic Gearshift Simulation for Commercial Vehicles, Proceedings of the 9th International Modelica Conference, 2012, 775-780.

[15] Ottorino Veneri, Clemente Capasso, Stanislao Patalano, Experimental study on the performance of a ZEBRA battery-based propulsion system for urban commercial vehicles, Applied Energy, 2017, 18(2), 2005-2018.

[16] Ioannis Kanellakopoules, Phyllis Nelson, Oscar Stafsudd, Intelligent Sensors and control for commercial vehicle automation, International Federation of Automatic Control, 23(1999), 117-124.

[17] John H. L. Hansen, Wooil Kim, Pongtep Angkititrakul, Advances in Human-Machine systems for In-Vehicle Environment, HSCMA, 2008, 128-131.

[18] N.P. Chai, W.A.W.Z. Abidin, W. H. W. Ibrahim and K. Hong Ping, Technology Advancement in Vehicle Monitoring System for Accident Prevention, UNIMAS E-Journal of Civil Engineering, 2012, 3(special Issue), 24-33.

[19] Juan de Santiago, Hans Bernhoff, Boel Ekergård, Sandra Eriksson, Senad Ferhatovic, Rafael Waters, Mats Leijon, Electrical Motor Drivelines in Commercial All-Electric Vehicles: A Review, IEEE Transaction on Vehicular Technology, 2012, 61(2), 475-484.

[20] S. Cecchel, D. Ferrario, Numerical and experimental analysis of a high pressure die casting Aluminum suspension cross beam for light commercial vehicles, La Metallurgia Italiana, 2016, 41-44.

[21] Abhishek Anchan, Challenges & Emission Control Technologies for Heavy-Duty Commercial Vehicles to meet Bharat Stage VI Norms: A Review, International Research Journal of Engineering and Technology (IRJET), 2018, 5(12), 993-1001.

[22] Troy R. Hawkins, Ola Moa Gausen, Anders Hammer Strømman, Environmental impacts of hybrid and electric vehicles—a review, International Journal of Life Cycle Assess, 2012,17,997-1014.

[23] Pavlos S. Kanaroglou, Ron N. Buliung, Estimating the contribution of commercial vehicle movement to mobile emissions in urban areas, Transportation Research Part E, 2008, 44, 260- 276.

[24] R S Krishna, Conversion of Diesel Engine to CNG Engine of Commercial Vehicles and Emission Control, International Journal of Mechanical and Production Engineering, 2018, 6(11), 71-76.

 DOI : 10.36893.DRSR.2021.V08I14.157-163