Hindawi
International Journal of Photoenergy
Volume 2022, Article ID 3053953, 8 pages
https://doi.org/10.1155/2022/3053953

Research Article

Designing the Modern Dual-Engine Two-Speed Smart Hybrid Electric Drive Powertrain

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Received 10 February 2022; Accepted 1 April 2022; Published 9 June 2022

Academic Editor: Ahmad Umar

While potential for battery-powered electric vehicles (BEVs) is increasing as the need to minimise greenhouse gas pollution and the utilization of energy production, the restricted driving range and the uninviting market price constitute BEV obstacles to reliable assessment as a conventional car. This paper suggests a double-motor multispeed direct-drive BEV drivetrain to improve average engine running performance in everyday travelling whilst raising any production or control sophistication, effectively saving minimal battery resources and production costs. The characteristics of the proposed drivetrain are first defined through quantitative and visual measurements, which divide the conventional one-engine propulsion to two with different permanent gears to optimise engine performance. Centred on dynamic powertrain modelling in Simulink, the economic change strategy and circulatory system consisting transfer control were planned and checked. Based on the simulation performance, it is stated that substantial increases in energy quality can be accomplished. Thanks to the optimised torque transfer control technique, the vehicle's incredibly low pull is registered during the shifting phase. Finally, it can be inferred that the suggested dual-motor drivetrain is better than the conventional single-motor equivalent in terms of fuel efficiency, driving range, and expense. There is substantial increase in total machine running areas of affordable to solitary machine performance and megacity driving ages, similar to WLTC, FTP-75, and JP 10-15, with 5 to 8 percentage performance enhancement being achieved.

1. Introduction

Rechargeable hybrid cars are now attracting increasing interest becoming ever more popular. However, compared to conventional cars, the comparatively limited driving range per fee, the prolonged recharge period, and the unfriendly price also pose major obstacles to its large-scale commercialisation [1]. While the improved catalytic and reliability output of the electrical system (engine), including the 100% displacement usable from dead stop and the significantly higher conversion efficiencies relative to the internal combustion engine (ICE), allows direct engine-to-wheel drive by a clutch automatic decrease, the requirement for alternative energy upgrade and better driving output has intensified. In our earlier work on BEV, a multispeed multigearbox transmitting structure including a hybrid microgrid was suggested [2]. Related plans for different microspeed transmitting applications in vehicles, such as automatic gearbox, Advanced Mechanical Transmitting and depending Distribution, can be found in. The findings of the above studies have clearly shown that multispeed transmission not only increases the dynamic and economic efficiency of BEVs, but also lowers high upfront costs by lower operational costs and repair charges in terms of long-term possession.

Additional benefits are also available for electric motors through speed control. However, the dynamic process, e.g. additional gear pairs, the unreliable hydraulic method and the synchronizer for gear shifting and the extra expense of transmission output, provide the obstacles to the effective translation of concepts into practise [3]. Even if some specifically made navigation systems are able to achieve seamless equipment changing by invigorating the throttle application process, the qualifications for rapid and precise motor as well as pneumatic cylinder power require considerable diagnostics and field checking [4]. The dual-engine multispeed direct-drive EV drivetrain has shown the ability to outperform the conventional single-engine fixed-speed drivetrain over perspective of business gain, by sacrificing on the flexibility of the design or management technique. It may be a viable choice for automakers to substitute the existing commonly used single-engine drivetrain throughout the short term [5].

Previously, given the large amount of surplus torque and strength lost in regular driving activities and the poor enhanced success, the planned drivetrain system divided one or two driving motors, addressing various driving trends [6]. Motor power and perpetual gear ratio are deliberately crafted to account for complex and commercial volumetric efficiency, followed by a quick and effective driving motor switching technique. In ensuring smooth propagation of the torque during speed control, the built shift control technique is then evaluated in a dynamic Simulink model.

Hybrid electric vehicles (HEVs), utilising an automobile and one and sometimes more electrical devices, are generally considered as the most suitable option for automobiles in the small to medium term. Battery vehicles automobiles are currently being produced by numerous manufacturers [7]. These cars are actually in service marketed as one way to increase the quality of our traffic process and make growing our reliance on and use of international petroleum. Latest research activities in REV are aimed at creating a fuel-efficient and cost-effective combustion device. Among a multitude of disciplines. Supercharged modes, the two widely recognised classifications are both sequence and parallel. Although the design of the series is effective for high energy requirements, the longitudinal hybrid is more suited for high road capacity requirements [8].

Autonomous driving Emulator (ADVISOR) was first established at the Regional energy technology Facility in November 1994. It was developed as an analysis platform to assist the US Department of Energy (DOE) in advancing HEV (Hybrid Electric Vehicle Propulsion) developments through contracts with Ford, General Motors and DaimlerChrysler. Its main function is to demonstrate the system-level engagement of hybrid and electric vehicles aspects and their effect on vehicle efficiency and fuel consumption. The overview of the drivetrain model which adapts the hybrid electric vehicle has been depicted in Figure 1 [9].

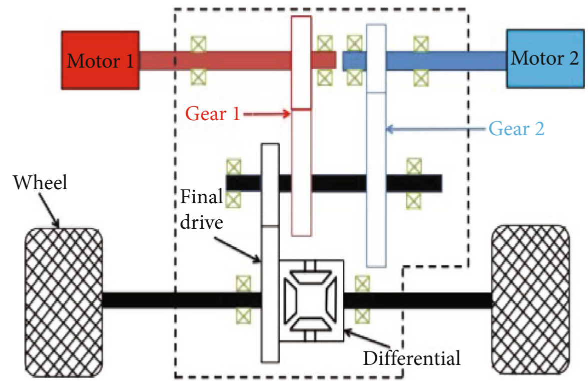

Figure 1: Overview of the hybrid drivetrain model.

Rather than strengthening BEV engine performance by providing new gears, a number of power splitting systems have been proposed to perform having similar inter-speed drivetrain functions that use engine power to shift directions and exchange acceleration among both gear teeth. Peng and He introduced a dual-engine drivetrain that utilizes multiple cruising engines and a double-input or double-output drivetrain to combine a set of driving configurations, e.g. high-speed four-wheel drive (FWD), low-speed Turbo and legitimate-wheel drive, via the two changing engines. It is an intelligent framework for the Manual transmission EV, but it is not a resource-friendly framework for the common two-wheel EV, taking into account the six-wheel drive, two synchronizers and two constantly changing stepper motors materials. Zhu et al. developed a multispeed two-wheel powertrain with an another-way gear box and a two-way shaft (inner and outer like a DCT). The efficiency of this proposed powertrain is relatively high compared to that of planetary gears, as is the cost of fast transmission regulations and the cost of production [10]. A two-engine drivetrain proposed by Hu et al. claimed about 4 percent enhancement in fuel consumption through some kind of planet-based power splitting system. Shifting of cruising modalities among single-engine train and the consolidated driver circuit in terms of consistency and ground clearance varies depending on a gear reduction unit, a clutch automatic unit, two shackles and a speed controller, making the composition more difficult. A further dual-engine drivetrain was used in the hybrid electric subway car with the new and innovative technologies technique [11].

Around the same moment, to care about saving expense of the engine, Wang et al. boost energy security by reducing this same effect of motor speed mutations on the transmission line. However, the coaxial dual-motor drivetrain structure can only provide an 'add-on' torque, rather than selecting the propulsion engine for efficiency [12]. Compared to the implementation of the significant ones-speed spread in BEV, the benefits of the above-mentioned a double-motor policy idea help reduce the incidence for transmission control in order to achieve quality shifting, in which the engines are actively engaged in the power splitting system to achieve smooth activation loop and driving product contains. In addition, the constructions increase the capacity of the multipowered torque/speed coupling modes. However, the clutches and/or the controller are still critical parts in the above proposals, which make a significant difference to the conventional BEV distribution service in terms of sector owned and enhanced mechanical performance [13, 14].

In comparison, neither the engine nor the accompanying gearbox of the above solutions was expressly built to have improved logistical and superior craftsmanship. Keeping in mind the different powertrain architectures proposed for multiple power source EVs, it is evident that most of them depend on shackles and synchronizers to accomplish their functions. A novel a double engine Two-Speed direct powertrain is proposed in this study, which seeks to make the most of the excellent engine torque delivery capability while at the same time simplifying the mechanical structure as much as possible, in order to improve engine operating efficiency without increasing the complexity of the control and mechanism [15]. Unlike other conventional BEV multispeed transmitting or energy dividing systems, this policy enforces a parallel osmotic pressure design in BEV, a famous hybrid vehicle drivetrain for engine and engine power flow management. The clear and relevant does have the power to remove the specifications of the clutch, speed controller and centrifugal pump for gear changing or cruising mechanisms switching. The role of the moving curves is realised by the flipping of the propeller engines of continuously joined mechanical parts [16].

The switching system is clearly governed by the engine, inevitably improving the efficiency of the drivetrain and reducing its physical sophistication [17]. In addition, trying to split a single fuselage engine to two raise the likelihood of maximum fuel operating efficiency by improving the design of the distinctive motor torque-speed and gear ratios. The benefit of adopting a two-speed drivetrain, instead of others, is that it can achieve the best balance of improvement in engine efficiency and an additional one through the implemented drivetrain and connected controller design, the testable focus of this article will fill the information gap of established work in the following areas:

(1) A famous 'one-engine yet another-speed' drivetrain is composed of two larger engines with roughly the very same maximum peak output throughout this article to promote better fuel consumption

(2) The method for evaluating the engine torque-speed profile of the conceptual engine and transmission offers the expertise and feedback on the power-efficiency-oriented configuration of the engine specifications

(3) In order to increase performance and facilitate effective transmission of energy, the substitute engine propulsion management method is planned and improved

(4) With the specially developed control approach, the 'multispeed' function is achieved by switching drive motors with persistently available gear pairs, rather than by involving the mechanical shift actuator, i.e. the clutch or actuator [18]

In the following chapters, the drivetrain requirements, which include electric engine and cornering speeds, are committed to even provide equal accuracy to the single-engine drivetrain optimization [19]. Driving vehicle shifting, which include gear trying to shift in this drivetrain, and friction transfer design methods are then suggested. Next, in MATLAB/Simscape R, dynamic simulation is used to replicate automotive output in traditional operating modes and to check the efficacy of the proposed management techniques [20]. Finally, based on a study of renewable energy, friction transmission performance in engine transferring and possibility financial advantages, statements are made that the implemented of double-motor 2-speed direct-drive drivetrain can also provide vehicle with significant quality and cost benefits for both producers and consumers. By increasing the operation speed, the torque requirement for the motor can be reduced, thereby reducing the motor volume and weight, and its power density increased with the speed [21]. The contribution of the work being summarised in Convergent Convertible Electric Vehicle Design with binary machine configuration, incorporating two "lower" effective machines, has the capability to increase machine performance. Also in Hybrid Engine Adaptive Modelling and Regulation Approach, when the speed increases, the energy reduces, owing to the power source of the machine batteries. Eventually in Results and Discussion, necklace comparison and motor effectiveness are being bandied.

2. Convergent Convertible Electric Vehicle Design

For both electric car and the diesel engine collaborate with each other to produce the vehicle's energy in a complementary hybrid car. The simultaneous hybrid can also be used by the engine to recharge packs generally fewer intense driving cycles, such as speeding at cruising speeds. Construction of rotating hybrid car. The connection between the electrical and the mechanical parts is visible. Energy storage connects to the servo motor via the power trolley and the electrical loads [22, 23], then the energy of the automatic transmission and the engine are integrated in the ground clearance coupling. The schematic architecture of the planned novel DMTS direct-drive powertrain shall not follow any clutch or speed controller. Each motor is attached to the final drive shaft by means of a fixed gear pair [24].

Due to the excellent engine torque power of 100 percent of the torque generated from dead stop, all competitive EV markets utilise a single-speed fixed-ratio modulation to minimise engine speed but at the same time boost the power. The rotation speed of the engine was dictated by the state of the vehicle and, as a result, high quality output could not be attained anywhere. As far as the engine output of the standard is concerned, the solid blue line reflects the necessary torque of the wheel at a grade of 30 per cent at 30 km/h, and is generally taken as one of the requirements for deciding the maximum torque requirement for the engine. If we can see, there is a large difference in these two criteria. In addition, the torque requirements of standard cycles show two simple patterns, namely significantly higher tension-low speed activities and significantly higher speed-low torque events, which could not be catered to a singular gear. Tracking maps show that enough surplus torque/power is seldom utilised in everyday driving, which ensures that most of the service tracks are far from high quality [25].

While a fairly small gear ratio will provide improved engine performance by raising the necessary torque of the engine, the need for a relatively large ratio of acceleration, scrambling and high-speed swerving eliminates the likelihood of a single-speed EV service. In order to increase the low regular running performance of a powerful engine with a high torque capacity, the reduction of the overall usable torque could boost the engine operating area and, as a result, increase the average energy conversion efficiency [26]. In addition, the accompanying set-up gear should be changed to accommodate for the disregarding engine torque.

The design of the two propulsion engines in the designed drivetrain must be carefully applied, as the allocation of existing between the two engines and the characteristics of the torque speed may influence the financial and kinetic efficiency. The overall volumetric efficiency of the standard drivetrain is as follows:

$$\mathrm{U}_{\max} = 276\,\mathrm{Nm} \times 8.8 = 2423\,\mathrm{Nm} \tag{1}$$

The driving range of 13000 rpm remains unchanged in the proposed approach. The cruising height of the goal of 160 km/h reached throughout the automobile will then be used to calculate the potential utilized to enable:

$$\alpha_{range} \le \left(\frac{2\pi M_{\max_{13000}}}{60} \right) \div \left(\frac{W_{\max}}{3} \right) = 13 \tag{2}$$

Extensive simulation findings from standard operating modes, the performance of the engine may be increased by increasing the working leverage and decreasing its rpm. Thus, a dual-engine configuration, incorporating two ‘less’ efficient engines, has the ability to increase engine performance by restricting the output spectrum to account for everyday driving activities and delivering at least the same overall torque and strength of a single-engine powertrain. Another of the engines is liable for lower turbo/energy moving activities, including such repeated city exits & rests and low-speed cruises. The other engine is used as an auxiliary battery pack during fast torque/power driving incidents, like emergency braking and high-speed trying to overtake. These two engines may operate together if the power of the single engine is inadequate under severe conditions [27, 28].

3. Hybrid Engine Adaptive Modelling and Regulation Approach

Then one microspeed EV drivetrain, that architecture and support programme of the suggested DMTS is clear. The choice to adjust gears, i.e. to turn among 2 propeller engines, is decided mostly by the performance of the engine, and can be accomplished by means of the engine speed controller itself. The basic approach guarantees that the car is still powered by a relatively higher performance engine at all point, unless the necessary torque should not be provided by a single engine [29].

As something of a consultant, the transverse electric assistance management technique utilises the electric motor as an additional power supply and battery capacity in the car. In this technique, the electric engine uses the following methods:

(i) When the speed of the car is below the posted level, the electric engine provides all the necessary torque of the vehicle

(ii) If the automobile torque needed is higher than the average rotational speed, the dc engine shall provide the supplementary kinetic energy

(iii) The electric engine loads the energy recovery electrodes

(iv) If the electric motor requires low driver behaviour and torque needs, the fuel consumption is shut off and the dc engine supplies the car’s torque demand

(v) If the SOC is tiny, the diesel engine must generate an additional torque. The parallel electrical assistance management technique for the contractor shall be calculated with six vector values

The electricity source utilises the most essential power suppliers for electrical parts such as traction and auxiliary converters for the provision of electrical power in automobiles. Battery packs have a crucial component to perform in electric vehicles and electric motors. Battery simulation is very complicated and challenging [30, 31]. The power model, then,

The Therapist has been used. Advisor consists of the following design battery cells:

(i) Resilient-capacitive model

(ii) Paradigm of input voltage

(iii) Simple lithium ion model

(iv) Model of the neural network

All of these models separated into other sections, e.g., shock resistant-capacitive framework includes of Li, ni-mh, supercapacitor. Gross domestic product voltage, appropriate monitoring and power capability are needed to pick the battery in HEVs. Even in Planner standby time and rechargeable battery weight are mentioned. Battery simulation in

Advisor requires to provide parameters for the battery. The SOC of the battery reduces at the initial period and rises when the engine is braked. The current of the battery relies on the speed of the car, so increasing the speed of the vehicle allows the SOC to decrease and the current of the battery to rise. If the SOC is the limit, the current of the battery is negative. When the current is positive, the vehicle uses the energy of the battery and when the current is negative, the battery is charged.

Driver circuit has been one of the essential features of HEV. Alluding to various operational ecosystems, such as straight course, downwind, descents, beginning-stop and so on, the engine performance mode must be switched between conditions of load condition, full load or overburden. The major point for the development of the engine as well as its control logic is therefore the improvement of the overall efficiency. Management quality specifications for the HEV engine and the steering system ought to have high systems with minimum loss, long cycle life, elevated torque at low pace, broad frequency adjustment range, high overwhelm capacity, good dependability, and so on. The voltage output of the electric engine is trying to follow the rated speed of the driving cycle. In functional central controls, the engine drive is attached to the VO board and the comparison displacement and rpm of the automatic transmission are calculated.

The acceleration formulas and the graphical diagram of the DMTS are implemented below in order to ensure a seamless transition of torque through gear teeth. A gear pairing continuously connected to the engine 1 comprises of gears 1 and 3; Pairs 2 and 4 reflect the reduction of the gear for engine 2; equipment, i.e. gearing pairs 5 and 6, push the board as shown in Figure 2.

K_{N1}, K_{N2} and K_{1-6} are representing the different power energy for the electrical motor, where as the different gears have been represented. The rotational latency of the motor has been represented by ω. Also, the speed that has been achieved by the rotational latency has been defined with $\dot{\omega}$. j_1 represents the range of gears between gears one and three. j_2 defines the same for the gears two and four. j_{last} represents the range of gears between gear five and six. U_{N1} and U_{N2} are defining the outcomes of the devices one and two and their outputs. U_L and U_{last} represents the outcomes of the shafts represented in Figure 2.So, the model can be derived as follows:

$$
\begin{gathered}
(K_{N1} + K_1)\dot{\omega}_{N1} = U_{N1} - U_1 \\
(K_{N2} + K_2)\dot{\omega}_{N2} = U_{N2} - U_2 \\
(K_3 + K_4 + K_5)\dot{\omega}_5 = j_1 U_1 + j_2 U_2 - U_L \\
j_6 \dot{\omega}_6 = j_n U_L - U_{last} \\
\dot{\omega}_5 = \frac{\omega_{N1}}{j_1}
\end{gathered} \tag{3}
$$

$$
\begin{aligned}
K_f \dot{\omega}_6 = {} & j_1\, j_{last} U_{N1} + j_2\, j_{last} U_{N2} - j_1\, j_{last}(K_{N1} + K_1)\dot{\omega}_1 \\
& - j_1\, j_{last}(K_{N2} + K_2)\dot{\omega}_2 - j_{last}(K_3 + K_4 + K_5) \\
& \times \dot{\omega}_5 - U_{last}
\end{aligned}
$$

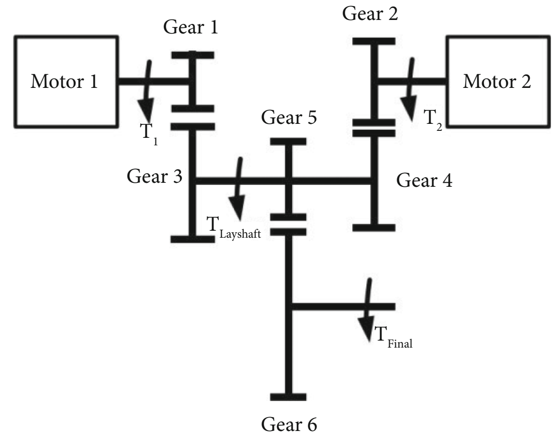

Figure 2: Gear structure.

and also,

$$
\begin{aligned}
K_f = {} & (K_{N1} + K_1) j_1{}^2 j_{last}{}^2 + (K_{N2} + K_2) j_2{}^2 j_{last}{}^2 \\
& + (K_3 + K_4 + K_5) j_{last}{}^2 + K_6
\end{aligned} \tag{4}
$$

Actually, looking at seamless displacement transition avoiding 'displacement crevice ' through spur shafts, the overall production velocity of DMTS on final straight would have been well held unvaried throughout switching phase. The variable speed drive engine is a device wherein the large conductive main source of energy supply a single power generation plant (electric engine) that drives the vehicle. The design that is most widely found in the Counsellor, the ICE would be used to produce energy in the engine. Application provides electricity for the engine and it was either an engine or an energy storage device. Electrical grid transforms the electricity of the motor into electric power. This energy may be contained in batteries or used for electric motors. Regulation technique is used to minimise fuel usage and emissions or to optimise battery life. The technique requires the following framework:

(i) We can turn off the SOC energy generator when growing

(ii) If the SOC is tiny, the electric motor must generate an additional power

(iii) Unless the automobile energy needed is greater than the normal motor speed, the automatic transmission shall provide the supplementary kinetic energy

In the SHEVs, the battery provides electrical strength to the electric motor along with the generator. The charging of the battery is assured either by electric motors or by the compressor. Full output of the electric engine is used where the combined strength of the steam turbine and the battery is greater than the electric motor. Battery energy must have vehicle acceleration capacity even in the toughest of circumstances. There must be certain parameters for emulation of electrodes.

Close to dual hybrids, the energy of the battery, the original contact of the batteries is 0.8 and the full energy for the batteries. When the speed increases, the energy reduces owing to the power source of the engine batteries. Processor is designed to avoid the degradation of energy. Current average energy is provided for the operator since energy is not less than the setting significance. Power of the engine operator in the combination sequence through it's a transformer. Transducer generates electrical power from battery but transformer it's energy. The position of the engine operator in the hybrid sequence is unique as well as an electric hybrid position. The engine is directly related to the powertrain and thus on the gears.

4. Results and Discussion

Focused on any of these approaches and design, the capital accumulation and competitive success of the suggested system is seen in this segment. In order to have greater viewership, the total engine design and resource usage in each standard loop are outlined just at early stages as a reference for more review. Figure 3 shows Torque comparison – 1.

The suggested methods have demonstrated that they are capable of minimising energy usage independently of traveling intervals. That being said, it may not work as well as boost engine efficiency in terms of the probability gain attributable to energy savings (regenerative braking) is omitted from this description, the output of which is heavily dependent on techniques but may also be enhanced by a for double-motor drivetrain. Figure 4 shows Torque comparison -2.

These methods produce substantial increases in total engine running area of affordable to solitary-engine performance. More than 12 percent increase in engine performance can be achieved and planned with the suggested methods in the highway driving trends. For other city driving periods, such as WLTC, FTP-75 and JP 10-15, 5%-8% performance improvement may be accessible. Attempting to compare methods, with the example of HWFET.

Figure 5 shows Shaft torque vs Time. Present comparable results in terms of average engine quality and energy usage. The reasoning for approaches to reasonably high-speed low-torque events offers more chances for the 100 Nm the proposed engine to work in a better energy zone, whereas the two proposed engines have a relatively wide torque capacity. However, in urban bikes, the benefit of a smaller torque capacity may be limited to some degree by a significantly larger torque requirement, particularly when the displacement efficiency of a slower driver in the suggested solution is inadequate.

Allowed to drive motor swapping may be used as a gear change in this analysis since each engine is permanently attached to a set gear ratio. Thanks to the excellent efficiency of the electrical motor (motor), i.e. the swift and precise answer to the challenging torque and pace, the torque is smooth and quick as in Table 1. Transferring from two engines can only be accomplished by regulating the turbine. The amount of the signalling gear does not change before the shifting phase has been finished. The criteria for preferred optimum turgidity of the automobile during conventional gear changes differs across areas. In order to assess the effect of the proposed powertrain on everyday driving for

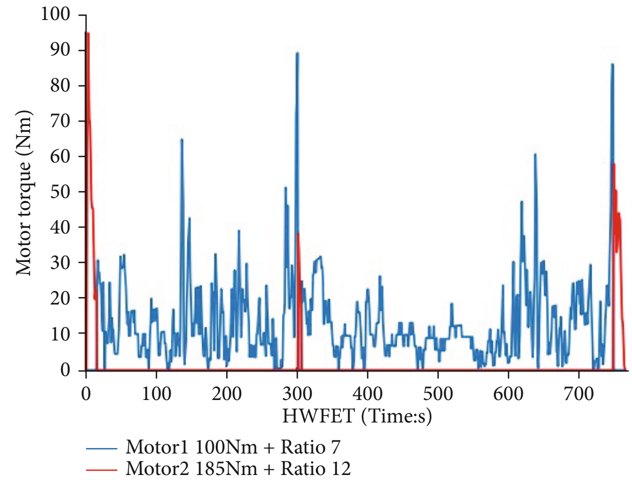

Figure 3: Torque comparison – 1.

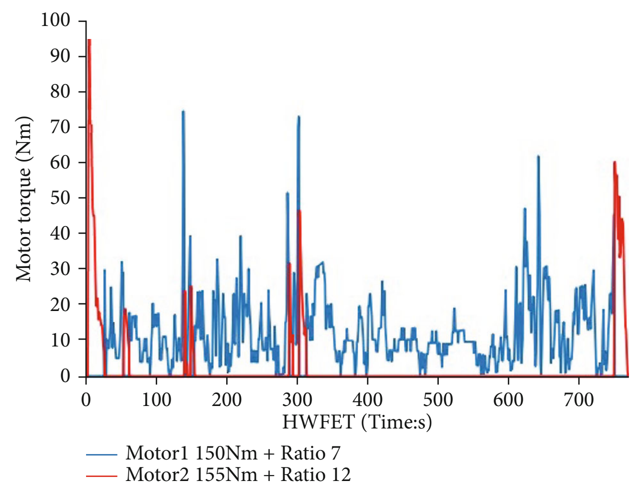

Figure 4: Torque comparison -2.

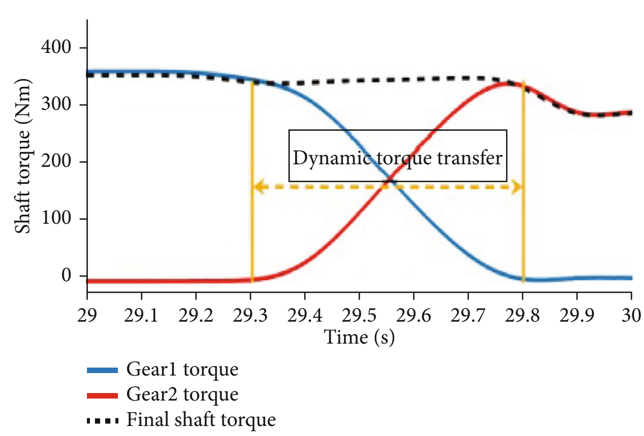

Figure 5: Shaft torque Vs Time.

Table 1: Efficiency estimation and comparison.

	Normal motor efficiency	Proposed system efficiency	Improvement
WLTC	82%	89.20%	7.20%
FTP-75	81.60%	90.40%	8.80%
HWFET	74.80%	81.20%	6.40%
JP10-15	85%	94.20%	9.20%

regular riders, a hybrid driving style is used to analyse the possible expansion of the driving range and the associated cost savings for BEV. The hybrid operating period implemented involves 57% of road driving and 43% of city driving, respectively.

It should be remembered that the aforementioned estimates do not consider losses in other machine systems, such as gear, axle, converter and associated systems, leading to higher than actual energy efficiency relative to the consumer product, e.g. e-Golf. However, because the detrimental variables have an effect on both traditional single-engine drivetrain systems, these statistics also have a strong overview and contrast to demonstrate the superiority of systems to a single-engine drivetrain.

5. Conclusion

Throughout this paper, a double-motor multispeed direct-drive Electric car drivetrain is suggested to enhance engine performance, effectively preserving minimal power consumption and cost of production. Originally, given the large amount of extra displacement and strength lost in regular driving activities and the poor overall performance, the planned powertrain system divided one or two driving motors, addressing various driving trends. Motor power and permanent gear ratio are specially engineered to account for complex and economic efficiency of the vehicle. A quick and effective moving motor swapping approach followed. In order to ensure smooth propagation of the torque through speed control, the built changeover control technique would then be evaluated in a flexible Simulink R model. Modelling of analysis showed that substantial increase in engine performance can be predicted with a pleased vehicle pull during shifting, i.e. less than $5\,\mathrm{m} = \mathrm{s}3$. Finally, the proposed dual-engine powertrain reveals the possible advantages for consumers and suppliers in terms of cost reductions in everyday travel and energy output. Overall, the dual-engine multi-speed direct-drive drivetrain has shown the ability to outperform the conventional single-engine fixed-speed drivetrain again from perspective of financial gain, despite sacrificing on the flexibility of the design or control technique. It may be a viable choice for automakers to substitute the existing commonly used single-engine powertrain in the immediate future. Substitute further may be grounded on electric powertrains, traction motor systems, crucial factors, and accoutrements in terms of the time frame by experimenters and masterminds in the unborn strategies in future.

Data Availability

The data used to support the findings of this study are included within the article. Further data or information is available from the corresponding author upon request.

Conflicts of Interest

The authors declare that there are no conflicts of interest regarding the publication of this paper.

Funding

This research work is not funded from any organization.

Acknowledgments

The authors appreciate the supports from Adams Science and Technology University, Ethiopia. The authors thank to *Wisma Lincoln,* Lincoln University College, Malaysia and Chennai Institute of Technology, Chennai for providing assistance to complete this work.

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