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Design of All Wheel Drive Electric Motorcycle & its Performance Analysis using Simulation software

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Abstract:

In India, domestic two-wheeler sales rise to 21.18 million units annually. Every average citizen prefers a two-wheeler. Often their bike gets stuck due to bumpy roads and mud, and due to less traction, the rear wheel starts spinning, in such situations either they have to push the bike or ask for help there are many off-road bikes available on the market, but they are too expensive. Once again, in this project, we faced a problem When a bike is stuck in mud or in a hole, the driver's legs are stuck on the ground to stop. In such conditions, the bike has to downshift to transfer more torque and power to the wheel, while the driver is in the mud it is difficult to lift his foot and change gear, with one leg on the gear shift can lose his balance and may have an injury. the Dynamic simulation model of an independent rear two-wheel electric vehicle was built by Matlab &SciLab Simulink software. BLDC motors were used in both drive wheels. The motor vector control algorithm and slip ratio differential control strategy are presented in this document.

Keywords —Vehicle dynamics,Modelling, simulation, Intelligent transportation systems,All Wheel Drive (AWD) Electric system, Brushless dc Hub Motor(BLDC)

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I.INTRODUCTION

Most EV motorcycles can't climb hills easily; it takes a long time to get on hilly roads compared to the highway because the engine inside is not very efficient to give them power. [1] This paper presents a Skylab with a Matlab blueprint and simulation of an electric motorcycle with an automatic gearshift design with an entire EV assembled to smoothly climb the EV motorcycle up a hill. [2] We have chosen the hero bike which is the best-selling motorcycle in India and converted it to an electric motorcycle with 82.54% efficiency in the FTP 75 Drive system. [3] Theoretical calculations and analysis of the electric motorcycle performance are performed to achieve a desired highly efficient electric motorcycle. [4]

The traditional rear-wheel drive motorcycle uses chains to transmit power from the engine to the rear wheel. But their applications are limited. The load capacity is limited. Climb ability is also limited as there is torque only on the rear wheel. [5] If the rear wheel slips, the vehicle will not move. This concludes that conventional motorcycles cannot be used comfortably uphill on steep roads, along muddy roads, on desert roads, on farmland, on mountains, etc. These motorcycles are also not suitable for off-road and adverse terrain. [6]

It's evident from the fact that a decade ago two-wheel drive motorcycles were limited to dirt racing and mountain racing. [7] But now they are sought after for agricultural and military applications, and more and more companies are showing interest in the two-wheel drive system on motorcycles. [8]

These vehicles do not fully exploit the fact potential of AWD motorcycles. Not being designed for intelligent management of the drive torque, they are unable to adapt the latter between the two wheels in various complex dynamic conditions. [9] The modulating distribution of torque between the wheels will give the designer greater control over the vehicle's performance and handling characteristics; this will be demonstrated in the paper in a simulation scenario, where the analysis of a typical curve will show how the advantages and disadvantages of AWD could be improved and mitigated, respectively by modulating the torque between the advantages and the traction hitches. [10] Available on the normally lowered wheel to improve acceleration and cornering stability, reduce the tendency of the rear wheel to slip, and apply useful thrust in the direction desired by the rider. [11] Testimonials from experienced pilots highlight these characteristics. The availability of adequate mathematical tools capable of capturing and describing these phenomena would facilitate the engineering development of such vehicle migration assessments for these new traction solutions. [12] This work aims to be the first step in a broader research work, which develops a model capable of laying the foundations for subsequent investigations of adequate control techniques that AWD can take advantage of the motors can be housed in the wheel assemblies of the vehicle bringing undoubted advantages such as a precise and rapid torque response, accurate control of the driving torque, and the possibility of obtaining useful information on the angular speed and on the torque of the wheel by measuring the electric current absorbed by the motor. [13-15]

II.METHODOLOGY

The concept of two-wheel drive motorcycles has not been implemented successfully and economically A two-wheel drive motorcycle is desirable in situations where there are rough terrain and high-grade roads that are tiring and difficult to ride with wheeled motorcycles. [16] A convertible motor to the front and rear wheels of the bike makes them EV drive. The lightweight "all mechanical system" is used to guide the sensations. Under optimal traction conditions, the rear wheel is actually driving faster than the front wheel, and the one-way clutch within the system allows the front wheel to spin freely under these conditions. [17] At this point, the two-wheel drive system is effectively passive. Although the front-wheel drive system is spinning, it's not actually transferring power to the front wheel. [18] When the rear wheel loses traction, the gear ratio, relative to the forward speed, changes. The two-wheel drive system engages by transferring power to the front wheel until traction is restored to the rear wheel. [19]

The AWD system (which powers the front wheel) is operated at a slightly slower speed than the rear wheel (approximately 80%). [20] Under optimal traction conditions, the rear wheel is actually driving faster than the front AWD system. [21] One-way clutches inside the front hub allow the front wheel to rotate freely under these conditions. At this point, the AWD system is effectively passive. [22-23] Although the front AWD system is spinning, it is not actually transferring power to the front wheel. When the rear wheel loses traction, the gear ratio, relative to the forward speed, changes.

The front wheel should be assigned a higher gear ratio than the rear wheel, i.e. the front wheel rotates at a slower speed than the rear. [24] This condition is given to have a differential effect when the bike is making a turn. When a bike makes a turn, the bike turns relative to a point on the ground. [25] This way the front wheel will be turned at an angle to the bike and the rear wheel will be in line with the bike. If the front wheels drive faster than the rear wheels, the vehicle will experience a traction effect. [26] This will make it uncomfortable for the rider to correct balance when cornering. A faster rear wheel will also give directional stability when cruising at high speed. [27] Since the front wheel is at a lower speed, freewheels are used to prevent skidding. A freewheel is a clutch with the ability to transfer power only in one direction. [28] Therefore, under optimal traction conditions, the rear wheel is actually driving faster than the front AWD system. One-way clutches inside the front hub allow the front wheel to rotate freely under these conditions. [29]At this point, the AWD system is effectively passive and no power will be transmitted to the front. So the bike will act as an RWD vehicle. Thus the fuel consumption will not increase. [30] The way auto-shift works is like unpacking a bike downhill. The driver needs a peel, but due to gravity (which acts like rear-wheel drive), traveling faster than you are delivering power. When you get to the bottom of the hill and slow down (similar to what happens when the rear wheel spins), you will start giving power to the bike again. So only when the rear wheel loses traction on the road (the rear wheel simply spins without moving the vehicle) should the front wheel engage and drive the vehicle. Therefore, the AWD system is activated only when required. [31]

III. MODELING AND SIMULATION

The selection and operation of the components will be assumed as a brushless dc hub motor with torque of 30Nm, an electric current of 31.25 Amp, the electric potential of 48 Volt, power of 1500 watts, motor power of 4500 RPM, and Li-ion battery pack. 240-cell lithium with 12 series 20 configurations in the parallel, electric charge of 60 Ah, and the capacity of 3kWh. We achieved 82.54% efficiency in the FTP 75 Drive system. [32]

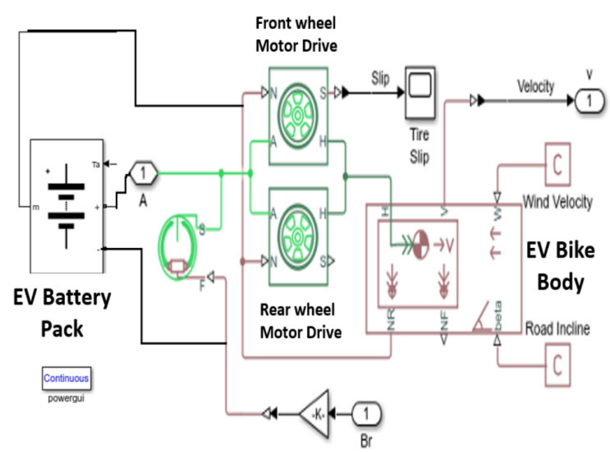

Fig. 1 Simulation Modelling of Electric motorcycle with Dual motor i.e. All wheel drive system.

->Wheel Torque(Nm)=Total tractive effort(N)*Radius of the Wheel(m)

->Wheel Speed(rpm)=Vehicle Speed(mps)*60/(2*pi*Radius of the wheel(m))

->Motor Speed(rpm)=Wheel Speed (rpm)* Gear Ratio

->Motor Useful Power=2*pi*Motor Speed(rpm)*Motor torque(Nm/A)/60

->Battery Power(Watts)=Motor Power/Motor Controller Efficiency (%)

->Battery Capacity(Wh)=Power per Km(Wh/km) *Range(km)

->Battery C-rate(C)=Battery Discharge Current(A)/Nominal Capacity of Battery(Ah)

->State of Charge (%) =100*(+ or -) integral(Current(A)/3600*Battery Capacity(Ah)) dt

->Motor Torque(Nm/A) =Wheel Torque(Nm)/Gear Ratio*Transmission Efficiency

Calculations &Assumptions: -
Gross Vehicle Mass(GVM)=324.775Kg
Gross Vehicle Weight(GVW)=GVM*g (g=9.81)
Radius of the Wheel=0.217m Coefficient of rolling friction=0.2
Aerodynamic force=148.011N (Drag coefficient=0.8, Frontal Area=1.087m^2, Density of Air=1.225, Velocity=16.67m/s)
Tractive Force=785.219N
Power required at Wheel=Tf*V=13.089KW
Power required at Motor=13.089KW CVT (Continuously Variable Transmission):
Gear Ratio =5.75
Wheel Speed=733.57 RPM
Wheel Torque=170.39Nm
Motor Speed=4220.5RPM
Motor Torque=29.56Nm Efficiency=82.54%

In addition, an optimal control algorithm for efficient performance will be developed to minimize energy losses using MATLAB / Simulink software just shown in figure 1. [33] Similarly, to demonstrate the effectiveness of all-wheel drive all-wheel drive, the torque control, and traction control simulation of the all-wheel drive electric vehicle will be compared with the unrestrained electric vehicle model. [34] Based on the result, torque vectoring and traction control of the in-wheel motor in an all-wheel drive electric vehicle can help increase the performance of the electric vehicle during peak. [35] In conclusion, this study of torque vectoring and traction control for Two-wheel drive will help experimenters improve the design of the future electric vehicle in terms of vehicle cornering performance. [36]

IV. SIMULATION RESULTS

The simulation results are shownin Figure 2,3,4 that the vector control for the BLDC motor has good stability, fast response, and small overshoot, and the slip ratio-based control strategy can meet the steering stability requirements. [37] Rear-wheel drive engines The initially started rear engine was successfully converted into a two-wheel drive motorcycle with automatic engagement within a certain time frame. [38]

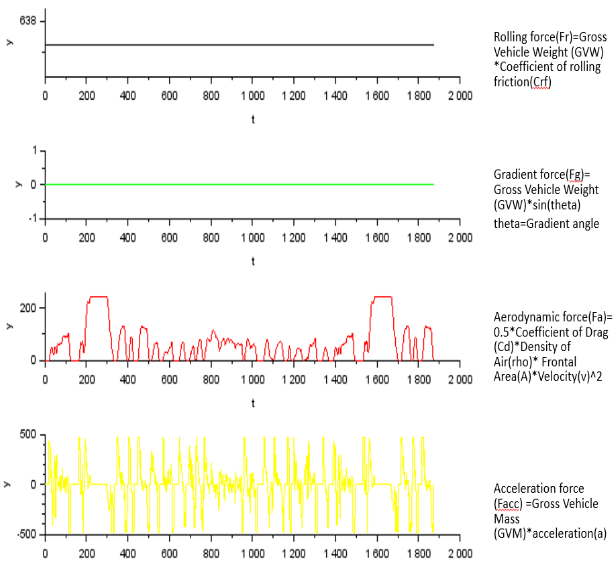

Fig. 1Simulation results for different tractive forces acting on the vehicle.

The automatic engagement of the front wheel was possible thanks to the use of a freewheel. At optimal freewheeling, the vehicle behaves like a rear-wheel drive vehicle and produces no problems. [39] The turning radius of the vehicle is 2.5 meters with an increase of only 0.5 meters from the initial condition. Since we have made a simple design, the weight of the vehicle has increased by only 6 kg and therefore there is not much variation in the fuel efficiency of the motorcycle. [40] The proposed symbolic model has been implemented in the Matlab Simulink software cross verified by Scilab. The comparative simulations, described in the next subsection, studied the reliability and effectiveness of the model in two noteworthy conditions: with roll and steering angles that exceed the linearization range; cornering acceleration of the AWD motorcycle when coupling dynamics are activated. [41]

The AWD system (which powers the forward wheel) is operated at a slightly slower speed than the rear wheel (about 80). [42] Under optimal traction conditions, the rear wheel is actually driving faster than the AWD system forward. One-way clutches inside the front hub allow the front wheel to rotate freely under these conditions. [43] At this point, the AWD system is effectively irresistible. Although the front AWD system is spinning, it is not actually transferring power to the front wheel. When the rear wheel loses traction, the transmission speed, relative to the forward speed, changes. [44] Furthermore, to simulate the equations of motion, the model proved effective in highlighting the effects of front-wheel drive on the dynamics of the motorcycle, allowing to describe the advantages and disadvantages of using AWD with torque distribution. [45]

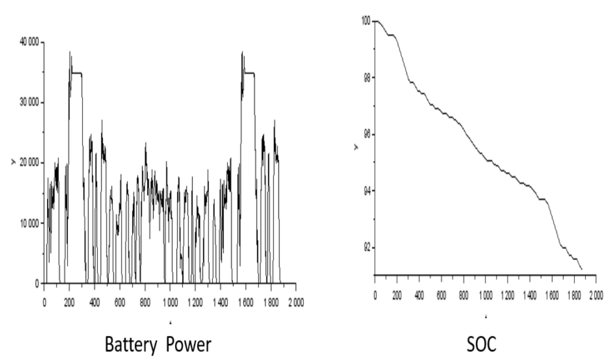

Fig. 3 Simulation results for battery parameter affected by dual motor drive.

The advantages and disadvantages of using the full rear-wheel drive or its nature distribution were highlighted and the results agree with the nature of an AWD motorcycle experienced by motorcyclists. [46]

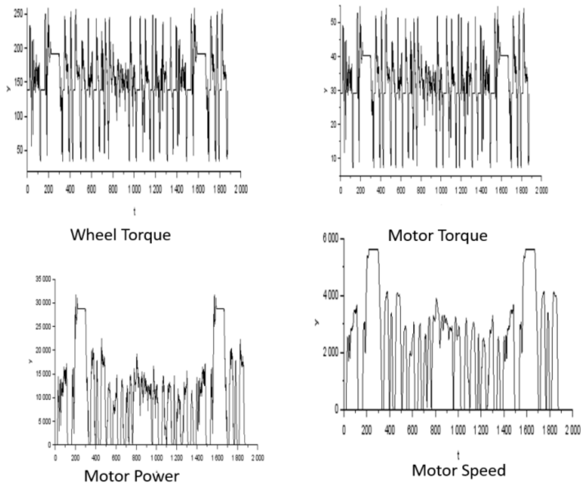

Fig. 4 Simulation results for both Motors parameters.

Future work will aim to investigate in more depth the best way to use the front-wheel drive in different scenarios, even in the presence of skidding conditions; this will be functional to the development of control systems that act adequately on torque distribution in order to obtain the improved vehiclesafety without hindering the driver. [47]

V. CONCLUSIONS

This paper presents a highly efficient electric motorcycle for easily climbing hills because the engine is now highly efficient for powering the electric motorcycle. [48] So the bike works more efficiently on rough terrain than a conventional bike, we were able to easily overcome a rocky and muddy road with this dual motor drive EV bike. [49] It doesn't take long to climb hill roads now because electric motorcycles have an automatic gearshift design with a whole electric vehicle assembled to smoothly climb the EV motorcycle up a hill. [50] We have achieved 82.54% efficiency in the FTP Drive system. The benefits of this highly efficient electric motorcycle proposed here include an easy mode of transportation and less stress for people moving on hilly roads, the use of a automatic variable transmission system, and a brushless hub motor to control range and torque in both wheels. [51] motor output to improve the total energy efficiency, we are having the advantages of desired torque and high efficiency which in turn helps us economically. [52] The performance of electric motorcycles will increase the lifespan of greentransportation which helps the Indian people and our nation, especially the people in the hilly areas, are very advantaged and this leads to national development in terms of better green transportation. [53] This paper addresses the problem of defining a viable symbolic model to describe the nature of torque distribution of an AWD motorcycle under different riding conditions. [54] The model is generally valid, that is, it was developed independently of the transmission technology adopted for the distribution of torque to the front wheel& rear wheel. [55] In this diary, the proposed highly efficient electric vehicle is detailed and Scilab simulations for the overall drive mechanism are provided. The conclusion report is generated by observing the theoretical data of the high-efficiency electric motorcycle with this dual Dc Hub brushless motor and the desired lithium-ion battery pack is specified and presented in the best possible way to design a high-efficiency electric motorcycle that is workable and in turn, offers an innovative reach in the appearance of electric vehicles. So it is important that all-wheel drive bikes on the road can be affordable to anyone at the minimum cost. [56-57]

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