Design of Alternative Automatic Transmission for Electric Mopeds

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Abstract— *The number of automobiles has seen an alarming rise in the recent years. In the year 2014, the number of road vehicles produced annually increased to 87.23 million vehicles from around 40 million in 2000. This shows that production has increased to more than twice the volume in only 14 years. This has also caused a rise in the pollution levels. Global CO2 levels are on the rise due to increased pollution, contributing to the greenhouse effect. Hence it is very important to reduce our dependency on gasoline driven vehicles. Electric vehicles are a good alternative to these. The advent of electric vehicles is marred by factors like unavailability of charging stations and most importantly not being able to match the performance parameters offered by gasoline driven vehicles. Hence a driveline setup has been designed to increase the performance parameters like gradeability and top speed of an electric moped to set it at par with the gasoline powered mopeds available on the market. In this report we will focus on the design considerations, working principle and the mechanism for the said driveline as well as the design calculations and the CAD model.*

Keywords— automatic, centrifugal clutch, drive train, electric vehicles, freewheel, mopeds, transmission.

I. INTRODUCTION

Electric vehicles are said to be the future of the automobile technology. There are overwhelming advantages of electric vehicles over gasoline vehicles. With gasoline-electric hybrid power and all-electric power, we can achieve significant cost and environmental savings. By adding more batteries and recharging capability to gasoline-electric hybrid vehicles, we can have plug-in hybrids that offer the range of hybrids (500 miles or more), plus the benefit of all-electric power for short trips, which dramatically reduces the amount of gasoline used. EVs require no gasoline whatsoever and, when recharged from renewable energy sources, produce zero total emissions. In fact, even if we switched from gasoline cars to EVs and plug-in hybrids recharged by our existing utility grids (which mostly use fossil fuels), we would see a 42% national average reduction in CO2 emissions, according to research by Peter Lilienthal of the National Renewable Energy Laboratory. According to a study, the yearly cost of operating 50 miles per gallon vehicle is $1275 while the same for operating an electric vehicle is just $216. The main issue with using an electric vehicle, in this case an electric moped is the lack of performance. Electric mopeds fall very short in the performance parameters like gradeability, torque and top speed as compared to the gasoline mopeds dominating the market today. The maximum speed possible with an electric moped is just around 16 mph as compared to 40-50 mph top speed of their gasoline counterparts. Hence a mechanical system has been designed which offers both greater power and greater torque whenever the situation demands the need for the same.

II. LITERATURE REVIEW

5V. B. Bhandari in his book Design of Machine Elements talks about the various power transmitting components, their application and design. The design methodology explained in the book is considered while design of mechanical components like the two-stage gearbox, input and output sprockets, gear shafts etc. 1In the book, Electric Vehicle Technology Explained, James Larminie and John Lowry explain the history and evolution of electric vehicles in terms of their technology and various features that have developed over the years. The book also talks about the various components of the electric drive system like the motor, their types and their development that improve vehicle characteristics such as speed, range, safety and reliability. 2F. K. Sully in Motor vehicle mechanic's Textbook emphasizes the importance of automatic transmissions in automobiles. He describes the common kinds of automatic transmission modes that are widely applied in current automobiles. The chapter talks about their advantages and disadvantages when used in different kinds of vehicles and ways in which they can be better implemented in the systems. 6The Motor Vehicle by T. K. Garrett, K. Newton and W. Steeds,

provides essential reference work for various transmission systems. It discusses in detail about the continuously variable transmission (CVT) and its components and how the system has been developed to be practically implemented in today's vehicles.

III. OVERVIEW OF COMPONENTS

The transmission system comprises of three main components namely a single-speed two stage gearbox, a centrifugal clutch and freewheels.

3.1 Gearbox

An automobile requires high torque while climbing hills and while starting. On the other hand, while running on high speeds on level roads, high torque is not required due to the vehicle momentum. The purpose of a gearbox in a vehicle is to vary the torque on the output shaft according to the required condition. Thus, the gearbox helps to convert the high speed low torque power generating device (engine, motor, etc.) to a high torque power transmitting system. In this system a single-speed two stage gearbox is used to increase the torque on the output shaft.

The main components of a gearbox are:

3.1.1 Counter shaft

Counter shaft is the shaft that is connected with the power producing device of the system. It is coupled with power transmitting devices like gears to transmit the power to the main shaft. The counter shaft runs with the same speed or different speed as that of the power producing device due to the gear ratio provided between them.

3.1.2 Main Shaft

The main shaft is the shaft which is coupled to the output shaft or the wheel. It carries power from the counter shaft by the use of gears according to the gear ratio and it runs at different speed and torque as compared to the counter shaft.

3.1.3 Gears

Gears are used to transmit the power from one shaft to the other. They are the most important components of the transmission system as they are responsible for the variation in the torque and speed of the gearbox. This takes place due to the gear ratio or reduction ratio of the gears. The gear ratio or the reduction ratio is the ratio of the driven gear teeth to the driving gear teeth. If the gear ratio is greater than one, the main shaft revolves at lower speed than the counter shaft and the torque on the main shaft is higher than the torque on counter shaft. On the other hand, if the gear ratio is less than one, the main shaft revolves at higher speed than the counter shaft and the torque on the main shaft is lower than that on the counter shaft.

3.1.4 Bearings

Bearings are used to support the rotating shafts and reduce friction. In the gearbox the main shaft and the counter shaft are supported by the bearings.

3.2 Centrifugal Clutch:

A clutch is a power transmitting component used to connect the driving shaft to the driven shaft, so that the driven shaft may be started and stopped at will, without stopping the driving shaft. A clutch provides an interruptible connection between two shafts. The driving shaft is connected to a boss assembly that consists of a number of shoes and springs that move radially outwards. The driven shaft is connected to another hollow boss. When the two shafts are aligned, the boss assembly can revolve inside the hollow boss. When the driving shaft is rotated, the centrifugal force due to rotation causes the shoes to move radially outwards and come in contact with the hollow boss of the driven shaft. With enough rpm and centrifugal force, the shoes maintain contact with the rim of the hollow boss, thus transmitting power from the driving shaft to the driven shaft.

The friction material used on the shoes and the inner rim of the hollow boss help in maintaining contact, while the spring ensures ease in expansion and retraction and hence provide effective power transmission.

3.3 Freewheel Sprocket:

A freewheel is a device in a transmission system that disengages the driveshaft from the driven shaft when the driven shaft rotates faster than the driveshaft. It uses a ratchet and pawl mechanism. It consists of two saw-toothed discs, pressing against each other, with the toothed sides pressing. When rotating in one direction, the saw teeth of drive disc lock with the teeth of the driven disc, making it rotate at the same speed. If the drive disc slows down or stops rotating, the teeth of the driven disc slip over the drive disc teeth and continue rotating. A freewheel sprocket has this mechanism enclosed in a boss and the teeth of a sprocket attached on the outer rim of the boss.

3.4 Sprocket:

A sprocket wheel is a power transmission device that looks like a profiled wheel with teeth or cogs that mesh with a chain, track or other perforated or indented material. The main difference between a gear and a sprocket is that gears mesh with each other while sprockets mesh with a chain which intern transfer power to other sprockets. They are useful in transmitting power when the shafts are located at a significant distance from each other.

3.5 Drive Shaft:

A drive shaft is a mechanical component used for transmitting torque and rotation, usually used to connect other components of a drive train that cannot be connected directly because of the distance or the needto allow for relative movement between them. The drive shaft is connected to the output wheels in an automobile that help in the forward locomotion of the vehicle.

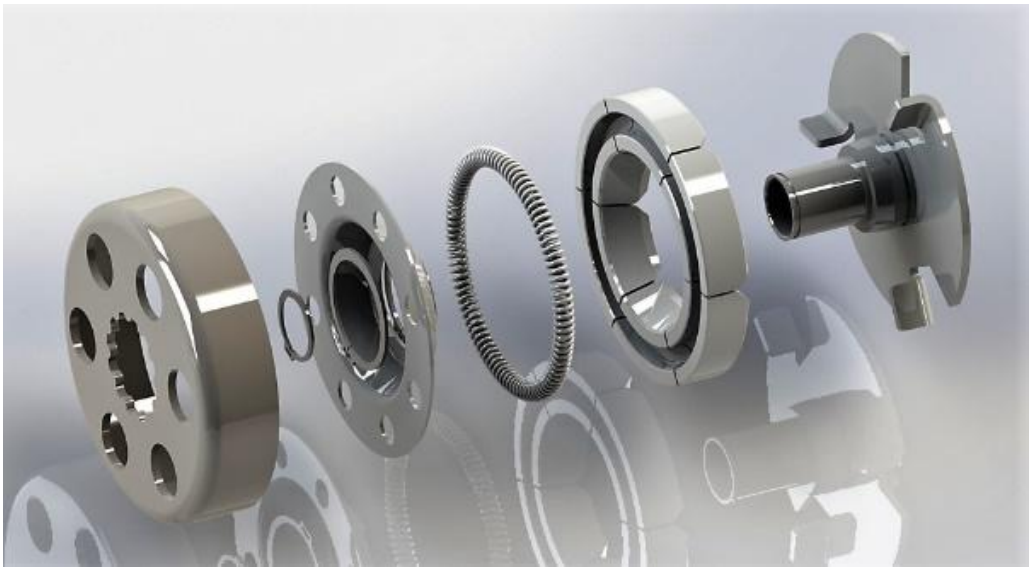

FIGURE 1: EXPLODED VIEW OF CENTRIFUGAL CLUTCH

IV. BACKGROUND

Currently various modes of power transmission are implemented in vehicles. The most common modes are variable speed gearbox, continuously variable transmission (CVT), torque converter and hub drive systems. These systems face drawbacks such as reduced transmission efficiency, lower torque transmitting capacity, increased driver discomfort and higher costs. The electric vehicles inherently face certain issues like lower speeds, lower vehicle range, lack of charging infrastructure and higher costs. For the newly growing electric vehicle market, the implementation of such systems with drawbacks will seriously affect their impact and necessity among the customers. Thus, it has become important to develop a transmission system which can be effective in not only eliminating these flaws but also increase the performance of the electric vehicles. This automatic transmission system for electric vehicles enhances the performance parameters of the electric vehicle by increasing the torque on wheels thus providing better acceleration and gradeability as well as increasing the velocity of the

wheel at higher motor rpm thus increasing the top speed of the vehicle. This system provides very high efficiency and reliability. It is compact, light in weight and economical to manufacture. Being an automatic system, it provides comfort and ease in driving. It is a unique transmission system that can be incorporated in the modern day electric vehicles.

V. CONSTRUCTION AND WORKING

Figure 1 shows the diagram of the Automatic transmission system for electric vehicles. The motor and the driven wheel are connected by the automatic transmission system. The power source is an electric motor that has a double-ended shaft to ensure that power can be transmitted from both the sides of the motor. The transmission system consists of two drivelines connected on either side of the motor. One driveline consists of the gearbox coupled to the driven wheel using a chain and sprocket arrangement on one side while the other driveline consists of the centrifugal clutch coupled to the driven wheel using another chain and sprocket arrangement on the other side. Both the driven sprockets that have been coupled to the driven wheel have attached freewheel units that help convert the conventional sprockets into freewheel sprockets. The freewheel sprockets are bolted to the driven wheel that help the power transmission to the wheel in a single forward direction. The working of the two drivelines is as follows:

5.1 Driveline 1:

As the motor rpm increases from zero, the motor shaft, which also acts as the input shaft to the gearbox and the boss assembly of the centrifugal clutch, starts rotating. This drives gears on the counter shaft of the gearbox which intern drive the gears on the main shaft due to meshing of the gears. As the gears provide a higher reduction, the main shaft rotates at lower speed and can deliver higher torque. The main shaft of the gearbox is connected to the wheel by a chain and sprocket combination of which the output sprocket is the freewheel sprocket. On the other hand, the boss assembly that houses the shoes and springs, also rotates inside the hollow boss. Due to lower motor rpm, the centrifugal force created due to rotation is less and thus, the shoes do not expand enough to rotate the hollow boss and thus the output shaft of the centrifugal clutch. Hence, the power is transmitted only through driveline 1 as the motor rpm progresses from zero to increased revolutions. As the overall reduction through the gearbox side is higher, the transmission can provide a higher torque during starting conditions, as well as for climbing grades, thus providing maximum acceleration to the vehicle, up to the point when driveline 2 is engaged.

5.2 Driveline 2:

As the motor rpm increases, a continuously increasing centrifugal force acts on the shoes of the boss assembly of the centrifugal clutch. At a particular rpm, the shoes expand radially outward to the point where they make contact with the hollow boss of the centrifugal clutch. This rpm is called engagement rpm of the driveline 2. Due to a higher coefficient of friction between the inner rim of the hollow boss and the surface of the shoes, the hollow boss starts rotating along with boss assembly thus transferring power from the input shaft to the output shaft of the centrifugal clutch. As the output shaft of the centrifugal clutch is coupled with the driven wheel by a chain and sprocket combination, the power can now be transmitted through driveline 2. The driveline 2 offers a much lower reduction thus increasing the rpm of the driven wheel which eventually increases the top speed of the vehicle. Owing to driveline 2, as the driven wheel now rotates faster than the driving shaft of driveline 1, by the principle of freewheel design (ratchet and pawl mechanism) the freewheel sprocket disengages the power from driveline 1, and now the power is transmitted only through driveline 2. Thus, when the vehicle starts from static position or is about to climb an incline, driveline 1 is engaged which provides the required high torque and thus maximum acceleration to carry out the task. Once the vehicle gains momentum and increases its speed, the driveline 2 is engaged which provides higher speed and increases the maximum speed of the vehicle. As the driveline 2 engages, driveline 1 is disengaged due to the freewheel mechanism.

VI. CONCLUSION

The proposed automatic transmission for electric vehicles provides better acceleration as well as velocity as compared to the electric vehicles with the same power range. Thus, a lower wattage power source can be used with this system, which will also help in reducing the battery pack size, eventually reducing the weight of the vehicle. This can help in achieving a better range for the vehicle. As the system incorporates components like the gearbox, centrifugal clutch, chains and sprockets, the transmission efficiency and reliability are high while maintenance and manufacturing time and cost are low. The automatic system is easy to drive for amateur drivers and provides comfort reducing driver fatigue especially while riding in traffic. Hence, with some research the automatic transmission system can be effectively used in most modern day electric vehicles.

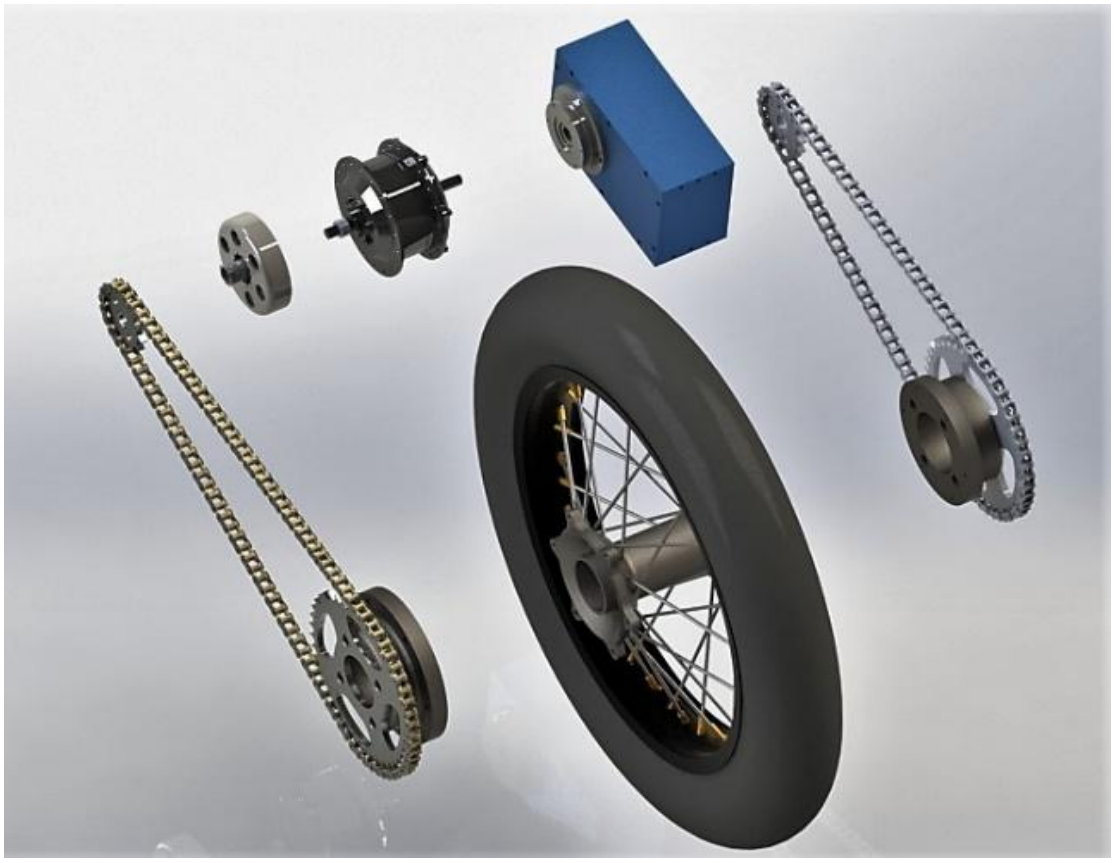

FIGURE 2: EXPLODED VIEW OF ENTIRE ASSEMBLY

VII. FUTURE SCOPE

- The study does not include any design values and figures as they may vary according to various designs and applications. While incorporating the system into a particular vehicle with specific parameters and requirements, the system can be thoroughly designed.
- The study also does not include the manufacturing methodologies and processes used to build the system. Thus, the final system costs cannot be determined.

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