ELECTRIC VEHICLE

Field of the Invention

The invention relates to an electric vehicle having attributes that improve energy efficiency in order to increase driving range.

Background of the Invention

The electric vehicle segment is experiencing rapid technological development. Most major car manufacturers either offer an electric vehicle for sale or have one in development. With the gradual but inevitable decline of fossil fuels, this upwards trend in the technological sophistication and availability of electric vehicles is set to continue.

Current battery technology provides limited energy density compared to liquid fuels such as gasoline and diesel. It is therefore important that the energy is used prudently in order to maximise the driving range of the electric vehicle.

Currently, manufacturers tend to base their electric vehicles on existing models but adapt them appropriately with suitable electric propulsion systems. Such an approach tends to be cost effective because it avoids the need for ground-up design to optimise the vehicle for electrification. However, this approach tends to miss opportunities for mass reduction and aerodynamic improvements which would improve the energy efficiency of the vehicle. Another approach apparent in the market is to focus on smaller vehicles as this generally keeps the mass of the vehicle low which improves the opportunity to extend the driving range. However, the size and ride comfort of such vehicles tends to limit their attractiveness to the buying public.

Summary of the Invention

The present invention provides an electric vehicle having a vehicle height of between 1600 mm and 1800 mm, a ground clearance of at least 260 mm, a wheelbase of between 3200 mm and 3350 mm, and a vehicle length less than 5100mm.

The vehicle therefore has a relatively high ground clearance, which has at least two benefits. First, the vehicle is better suited to travel over rough terrain. Second, the driver has a higher seating position, which promotes better visibility and safety. Existing vehicles having a high ground clearance also have a high vehicle height. By contrast, the vehicle of the present invention has a vehicle height of between 1600 mm and 1800 mm. This comparatively lower vehicle height has at least two advantages. First, a lower centre of gravity is achievable, which promotes better handling. Second, and perhaps more importantly, the lower vehicle height reduces the frontal area of the vehicle. Indeed, the vehicle may have a frontal area less than 2.7 square metres. As a result, the drag of the vehicle is reduced and driving range is increased.

There is an existing prejudice that, in order to reduce the drag coefficient of a vehicle, the vehicle should be designed such that the bulk of the air is forced over the top of the vehicle. Accordingly, when looking to improve the driving range, engineers will typically design a vehicle having a low ground clearance. The engineers responsible for the vehicle of the present invention have found that, contrary to current thinking, a relatively high ground clearance can be used without significantly impacting the drag coefficient.

Whilst the vehicle height and ground clearance of the vehicle have the advantage of reducing the frontal area of the vehicle, they have the adverse consequence of reducing the height of the passenger cabin. In order to compensate for this, the vehicle has a relatively long wheelbase of between 3200 mm and 3350 mm. As a result, a vehicle having a relatively large cabin capacity may be achieved. As well as achieving a large cabin capacity, a long wheelbase has at least two other advantages. First, a longer wheelbase generally provides for a more comfortable ride. Second, where the battery pack of the vehicle is positioned beneath the cabin, a longer wheelbase enables a larger battery pack to be employed, which then increases the driving range.

The vehicle has a vehicle length less than 5100 mm, and more preferably between 4700 mm and 5000 mm. Consequently, in spite of the long wheelbase, the length of the vehicle is not excessive, which aids in parking and low speed manoeuvring. The length of the vehicle relative to the wheelbase also results in relatively short overhangs. This then has the benefit of producing larger approach and departures angles. As a result, the vehicle is better suited at handling steep terrain and obstacles.

With the vehicle of the present invention, improved driving range may be achieved without compromising on cabin capacity or ride comfort. For an electric vehicle, where anxiety over driving is often cited as a barrier to adoption, any increase in driving range is hugely advantageous. Moreover, improved driving range is achievable in a vehicle having features typical of a sports utility vehicle (SUV), i.e. high ground clearance and elevated seating position. SUV is a vehicle segment that is enjoying significant growth, but superior efficiency is not normally a characteristic that is associated with this segment. With the vehicle of the present invention, an electric SUV having a good driving range is made possible.

The vehicle may comprise a driver seat having a seat height (i.e. the vertical distance between the H-point and the cabin floor) of between 260 mm and 300 mm. The driver therefore has a reclined seating position typical of a saloon or sedan vehicle. By contrast, conventional vehicles having a high seating position typically have a much taller seat height such that the driver adopts a more upright seating position. However, an upright seating position demands a taller passenger cabin. By having a relatively low seat height, the height of the cabin can be reduced. As a result, it is possible to achieve a vehicle having a low frontal area (i.e. vehicle height of between 1600 mm and 1800 mm, and a ground clearance greater than 260 mm) whilst also providing sufficient head room.

The vertical distance between the driver H-point and the ground may be at least 740 mm. The vehicle therefore has a relatively high seating position, which, as noted above, promotes better visibility and safety.

If the vehicle has a relatively low seat height, the horizontal distance between the front wheel axis and the driver H-point will increase. As a consequence, the driver is located further from the front of the vehicle. In order to compensate for this, the vehicle may have a relatively short front overhang. In particular, the vehicle may have a front overhang less than 850 mm. Consequently, in spite of the low seat height, the distance between the driver and the front of the vehicle need not be excessive. The driver is then better able to gauge the front extremity of the vehicle, which in turn eases parking and low-speed manoeuvring.

The vehicle may comprise a battery pack positioned beneath the cabin of the vehicle. Owing to the relatively long wheelbase, the space beneath the cabin provides useful real estate. As a result, a relatively large battery pack may be employed. Locating the battery pack beneath the cabin has the further benefit of lowering the centre of gravity of the vehicle, which helps promote better handling. However, locating the battery pack beneath the cabin is not without its difficulties. In particular, the battery pack is vulnerable to ground impact or intrusion. Nevertheless, with the vehicle of the present invention, the relatively high ground clearance significantly reduces this risk.

In spite of the relatively long wheelbase, the high ground clearance makes it possible to achieve a relatively high breakover angle. In particular, a breakover angle of at least 20 degrees is possible. As a result, the vehicle continues to be well suited to travel over rough terrain in spite of the long wheelbase.

The vehicle may have a front overhang less than 850 mm and a rear overhang less than 950 mm. The overhangs are therefore relatively short, making it easier to park and manoeuvre the vehicle at low speed. Shorter overhangs have the further benefit of producing larger approach and departures angles. As a result, the vehicle is better suited at handling steep terrain and obstacles. When combined with the claimed ground clearance, the vehicle may have an approach angle and a departure angle of at least 25 degrees.

The aerodynamic drag coefficient of the vehicle is influenced by the angle of inclination of the windscreen. In particular, as the inclination angle (relative to the horizontal plane) decreases, the drag coefficient decreases. However, as the inclination angle decreases, the overall size and thus mass of the window increases, which impacts the cost and driving range of the vehicle. Additionally, as the inclination angle decreases, the seating position of the driver is pushed further rearward. As a result, the driver may have greater difficulty in estimating the front extremity of the vehicle, which then has implications for parking and low speed manoeuvring. Finally, as the inclination angle decreases, optical distortion may become a problem. Accordingly, the windscreen of the vehicle may be inclined at an angle of between 25 and 30 degrees relative to the horizontal plane. This has been found to provide a good balance between the various competing factors.

The vehicle has a vehicle height of between 1600 mm and 1800 mm and a ground clearance of at least 260 mm. More particularly, the vertical distance between the roof of the vehicle and the underside of the vehicle may be between 1340 mm and 1465 mm. This then provides a good balance between the need to reduce the frontal area whilst providing sufficient cabin height.

The vehicle may comprise a body and a windscreen, and the horizontal distance between a leading edge of the body and a leading edge of the windscreen is less than 870 mm.

The vehicle may comprise a relatively short front section which enables a comparatively larger cabin space. For example, the windscreen of the vehicle may have a leading edge that begins only a short distance behind the front wheel axis. Furthermore, the horizontal distance between leading edge of the body and the leading edge of the windscreen may be less than 870 mm. Positioning the windscreen in a relatively forward position enables the front row of seats to also be positioned in a relatively forward position which, together with the unusually long wheelbase, increases the spaces for the second row of seats and third row of seats, if provided.

The vehicle may comprise wheels having an outer diameter of between 45% and 55% of the vehicle height. The wheels of the vehicle are therefore relatively large as a percentage of the vehicle height. Wheels of this size have the benefit of significantly reducing the rolling resistance of the vehicle. As a result, an increase in the driving range may be achieved. The size of the wheels also makes possible the relatively high ground clearance, which in turn enables a high seating position. A high ground clearance and high seating position may alternatively be achieved using smaller wheels and a raised suspension. However, this then compromises the handling of the vehicle, and the resulting driveshaft angle will lead to increased joint wear and vibration. By employing relatively large wheels, a relatively high seating position may be achieved whilst also promoting good handling. Additionally, a relatively high ground clearance may be achieved with a shallow driveshaft angle.

There are a number of prejudices that would deter an engineer from employing wheels of this size. First, larger wheels have a greater moment of inertia and therefore require more energy to accelerate and decelerate. There is therefore an existing prejudice that larger wheels are less efficient and will decrease the driving range of a vehicle. Second, there is an existing prejudice that wheels of this size would worsen ride comfort due to the larger unsprung mass. Third, larger wheels require a larger space envelope. In particular, as the size of the front wheels increases, deeper wheel arches are required in order to accommodate the wheels during turning. For a conventional vehicle having an internal combustion engine (ICE), deeper wheel arches are possible only by increasing the vehicle width; this is because it is not normally possible to reduce the size of the engine bay or the location of the front longitudinal members. Manufacturers of ICE vehicles looking to produce an electric vehicle would continue to use the body of the ICE vehicle owing to the huge expense associated with redesigning the body. When designing an electric vehicle, engineers would not think to use wheels of the size presently claimed. The engineers would understand that to do so would require a significant increase in the vehicle width or a fundamental redesign of the body. Any increase in the vehicle width will increase the frontal area of the vehicle and thus decrease the driving range, whereas a fundamental redesign of the body would be hugely expensive without any perceived benefit.

With the electric vehicle of the present invention, the engineers had to overcome many existing prejudices. In doing so, the engineers discovered that the provision of large wheels can bring about significant and often surprising technical benefits. In particular, the engineers identified that, for an electric vehicle, energy may be recovered during braking which can help mitigate the higher inertia associated with larger wheels. Moreover, the engineers observed that the decrease in the rolling resistance that is achieved at this wheel size can offset the increase in inertia such that a net gain in the driving range may be achieved. The engineers also recognised that, by employing larger wheels, a given load index can be achieved for a lower tyre pressure. By reducing the tyre pressure, a more comfortable ride may be achieved. The engineers further recognised that wheels of this size can be employed without unduly increasing the vehicle width. In particular, the engineers recognised that the size of the front bay of the vehicle, which is conventionally occupied by an engine, may be reduced by locating elements of the powertrain elsewhere, e.g. by locating the battery pack on the underside of the vehicle. As a result, the vehicle body may be designed with a narrower front bay such that deeper wheel arches may be achieved for the same vehicle width. Consequently, it is possible to employ wheels of the size presently claimed in an electric vehicle without unduly increase the vehicle width and thus the frontal area of the vehicle.

The wheels may have a section width of between 27% and 32% of the outer diameter of the wheels. Consequently, the wheels are relatively narrow. A narrower wheel has the advantage of reducing the mass and frontal area of the vehicle, thereby increasing the efficiency and driving range. However, as the width of the wheel decreases, the load index decreases. An electric vehicle is typically heavier than an equivalent ICE vehicle owing to the mass of the battery pack. As a result, wheels having a higher load index are required. The engineers responsible for designing the vehicle of the present invention were advised by tyre manufactures that wheels at these dimensions would fail to provide a sufficient load index. However, the engineers found that, by employing a section width of between 27% and 32% of the outer diameter, sufficient load index may be achieved whilst also providing a significant reduction in mass and frontal area. More particularly, the engineers found that a relatively good balance in the competing factors (e.g. rolling resistance, inertia and load index) may be achieved by employing wheels having an outer diameter of between 800 mm and 850 mm, and a section width of between 235 mm and 255 mm.

The wheels may have a section height of between 80 mm and 135 mm. For a wheel having a given rim diameter, the rolling resistance decreases as the section height increases. Additionally, as the section height increases, a lower tyre pressure may be used to achieve a given load index, which then improves ride comfort. However, as the section height increases, the inertia of the wheel increases. A section height of between 80 mm and 135 mm has been found to provide a good balance between the competing factors of efficiency, comfort and load index.

As noted above, the engineers responsible for the present invention recognised that the width of the front bay of the vehicle may be reduced by locating elements of the powertrain elsewhere. As a result, it is possible to employ large wheels without unduly increasing the vehicle width and thus the frontal area of the vehicle. Indeed, the vehicle width may be less than 1975 mm. This is then comparable to some SUVs, and is significantly less than other SUVs for which the vehicle width is greater than 2000 mm. The technical benefits associated with having large wheels can therefore be achieved in an electric vehicle with a vehicle width comparable to that of existing SUVs.

Within the scope of this application it is expressly intended that the various aspects, embodiments, examples and alternatives set out in the preceding paragraphs, in the claims and/or in the following description and drawings, and in particular the individual features thereof, may be taken independently or in any combination. Features described in connection with one embodiment are applicable to all embodiments, unless such features are clearly incompatible.

Brief Description of the Drawings

In order that the invention may be more readily understood, reference will now be made by way of example only to the accompanying drawings in which:

Figure 1 is a side view of a vehicle according to an embodiment of the invention;

Figure 2a is a front view of the vehicle in Figure 1, whereas Figure 2b is a depiction of the vehicle frontal area;

Figure 3 is a cross-section through one of the wheels of the vehicle in Figures 1 and 2, taken along the vertical plane of the wheel; and

Figure 4 is side view of the vehicle, like that in Figure 1, but which shows the body proportions of the vehicle in terms of wheel diameters.

Detailed Description of the Invention

Referring firstly to Figures 1 and 2, a vehicle 2 is shown that is configured for implementation as an energy efficient electric vehicle. In this context, the vehicle may be fully electric, as would be powered by one or a combination of a battery pack, a hydrogen fuel cell and photovoltaic cells, or it may also be a hybrid electric vehicle that combines an electric prime mover with an internal combustion engine, such as a gasoline, diesel or gas engine, for example. Since this discussion is concerned with the overall configuration of the exterior attributes of the vehicle 2, it will be appreciated that the precise form of motive power sources used in the vehicle are not the focus of the discussion and so are not shown in the drawings. However, as an example, the vehicle 2 may be provided with a battery pack 4 positioned generally in a body 6 of the vehicle, and one or more electric motors. Here, one or more electric motors 8 are provided to drive front wheels 10 of the vehicle, and one or more electric motors 12 are provided to drive the rear wheels 14 of the vehicle 2. Here, each of the wheels 10,14 comprises a tyre 11 mounted on a wheel rim 13.

In overview, the vehicle body 6 comprises a vehicle roof 20 which defines the upper surface of the vehicle 2 extending rearwards from a windscreen 22 of the vehicle towards the rear of the vehicle, a front section 26, a rear section 28, and a vehicle underside 30.

A significant advantage of the vehicle 2 is that it is configured to achieve a long driving range and to be comfortable for its occupants whilst minimising the aerodynamic compromises that are usually made whilst meeting this design objective. This is achieved generally by a combination of the vehicle length, its frontal area, and the ground clearance of the vehicle. These vehicle attributes will now be discussed in more detail.

Notably, the vehicle length in the illustrated embodiment is between 4700mm and 5000mm, and currently preferred is about 4900mm. In some embodiments the vehicle length may be up to 5100mm or more, and may be as low as 4550mm. The length is indicated by dimension D1 on Figure 1. Figure 1 also shows many other vehicle dimensions and these will be discussed below in more detail. As will be apparent, the considerable length of the vehicle ensures that plentiful cabin space is provided in the vehicle, thereby benefitting passenger comfort, despite the constraints imposed by a relatively limited frontal area which is desirable from a drag perspective.

The skilled person will appreciate that the main contributors to frontal area are the vehicle height, the vehicle width and the ground clearance. These are best appreciated from Figure 2, on which these dimensions are labelled. Turning to Figure 2, the vehicle has an overall width (indicated as D2) between the vehicle flanks of between 1925mm and 1975mm. Currently it is envisaged that the width will be about 1950mm, although any width between the previously mentioned boundaries is considered acceptable. The track width of the vehicle is also shown on Figure 2, as indicated by D2’, and is greater than 1600mm. In the illustrated embodiment the track width is 1685mm.

The height of the vehicle 2, as is indicated as D3 on Figure 2, may be between 1600mm and 1800mm, for example between 1650mm and 1700mm, or even between 1650 and 1680. The height is currently envisaged to be about 1660mm. Note that the height dimension is measured from a theoretical ground plane G on which the vehicle rests with a nominal load and extends to the horizontal projection of the uppermost vertical point of the vehicle roof.

The ground clearance of the vehicle 2 is indicated on Figure 2 as D4 and is the distance between the ground plane G and the vehicle underside 30. As can be seen in Figure 2, the vehicle underside 30 is relatively flat without any significant protuberances and as such may be defined by an aerodynamic undertray to improve the flow of air under the vehicle when moving. The ground clearance D4 is comparatively large in this embodiment, being at least a nominal distance of 260mm in this embodiment. It is currently envisaged that the maximum nominal ground clearance will be about 310mm by way of example, and currently preferred is 300mm. Note that the vehicle may be supported on adaptable suspension which provides the facility to vary the ground clearance of the vehicle, for example based on driving modes. During highway driving for example, the suspension may be selectively adaptable to lower the ground clearance of the vehicle, whereas during urban driving or in off-road conditions the suspension may adapt to raise the ground clearance of the vehicle. In such an embodiment, the suspension may be configured to be able to adjust the ground clearance of the vehicle within the range of about 200mm to 350mm. As will become apparent, the aforementioned ground clearance is relatively high in comparison to the position in which the passengers sit in the vehicle. The high ground clearance is in part enabled by the wheels which have a surprisingly large outer diameter compared to the other dimensions of the vehicle. This aspect will be discussed later. However, it is notable that the height of the vehicle is relatively low compared to its length, for example between about 30% and 37% of the overall length of the vehicle. Also, the vertical distance between the underside of the vehicle and the vehicle roof height (D3-D4), as compared to the length of the vehicle, is between about 25% and 30%.

The combination of vehicle height, width, ground clearance and the overall vehicle profile as discussed above provides a frontal area of between about $2.5m^2$ (square metres) and about $2.7\ m^2$ which is comparatively small for such a large vehicle and therefore is a strong factor in promoting good aerodynamic efficiency of the vehicle, which is a function of frontal area and the drag coefficient (C_d) of the vehicle, as would be understood by the skilled person. To avoid doubt, the term ‘frontal area’ is being used here to have the accepted industry meaning as being the area of the vehicle as seen from the front of it, for example, the area of an image of the vehicle projected on a vertical surface at the front of the vehicle by a light source behind the vehicle. A depiction of the frontal area of the vehicle is shown in Figure 2b labelled as ‘A’.

To offset the relatively small frontal area, the length of the vehicle provides a large cabin space for accommodating passengers and luggage. The available cabin space is maximised by configuring the vehicle 2 with a relatively long wheelbase, being is the horizontal distance between the front and rear wheel axes as indicated by D5 in Figure 1. The relatively long wheelbase also benefits the comfortable driving dynamics of the vehicle. In various embodiments the wheelbase may be between 2950mm and 3350mm, preferably between about 3000mm and 3350mm, more preferably between 3200mm and 3350mm. It is envisaged that the wheelbase is about 3335mm. It should be appreciated that the wheelbase is relatively long in comparison to conventional passenger vehicles and this contributes to good stability over undulating road surfaces.

Taken in conjunction with the length of the vehicle, the relatively long wheelbase D5 positions the wheels 10,14 towards the four corners of the vehicle 2 which means that the vehicle body 6 can be configured to provide a large area between the front and rear wheels as cabin space or to house equipment. Figure 1 shows an example of this, in which the battery pack 4 is positioned beneath the cabin of the vehicle between the front and rear wheels 10,14. The relatively long wheelbase means that the floor area for the battery pack 4 is maximised and so, for a given battery volume requirement, the battery pack 4 can be made relatively long and shallow to make effective use of the floor area of the vehicle. This also provides useful real estate to install a larger battery pack so as to take advantage of the increased energy storage and discharge characteristics that a larger battery pack allows, and contributes to lowering the centre of mass of the vehicle.

The length of the wheelbase D5 compared to the overall vehicle length D1 results in the vehicle 2 having short front and rear overhangs. In Figure 1, the front overhang is defined by the front section 26 of the vehicle and is indicated by reference D6, being the horizontal distance between the front wheel axis X1 and the front most edge, or the leading edge 40 of the vehicle. Similarly, the rear overhang is defined by the rear section 28 of the vehicle 2, and is indicated by reference D7, being the horizontal distance between the rear wheel axis X2 and the rear most edge or trailing edge 42 of the vehicle.

In this embodiment, the front overhang dimension may be about 820mm. However, it is envisaged that the front overhang dimension may be in the range of between about 750mm and 850mm. The rear overhang dimension is similarly short and in the illustrated embodiment may be about 900mm, although it is envisaged that a rear overhang in the range of 850mm and 950mm will be acceptable. The short overhang dimensions D6, D7 of the vehicle 2 mean that the length of the wheelbase is maximised given the length of the vehicle, and they also contribute to providing the vehicle with desirable handling characteristics due to the reduction of mass located beyond the wheelbase of the vehicle. Furthermore, the short overhangs benefit low speed manoeuvring since the driver of the vehicle can readily estimate the extremities of the vehicle. Linked to the short front and rear overhangs are front and rear breakout angles of the vehicle, A1 and A2. These may also be known as the approach and departure angles, respectively. Beneficially, the front and rear breakout angles are configured to be relatively large due to the short respective overhangs and the relatively high ground clearance of the vehicle as will be discussed in further detail later. In the illustrated embodiment, the front breakout angle A1 and the rear breakout angle A2 are approximately 30 degrees but may be between 25-35 degrees. The relatively large breakout angles benefit the ability of the vehicle to deal with steep terrain and obstacles.

As has been mentioned above, the overall configuration of the vehicle provides a relatively small frontal area for such a large vehicle, but the length of the vehicle maintains a useful internal cabin volume which can accommodate passengers, luggage and other equipment. Currently it is envisaged that the vehicle would be equipped with up to seven seating locations, for example arranged in three seat rows, as is the case with the illustrated embodiment. Conventionally, a vehicle with such a passenger capacity would have a much larger frontal area, but the vehicle of the invention is configured with a small frontal area which improves its drag coefficient whilst retaining a cabin capacity for up to seven passengers.

Further improvements in aerodynamic efficiency are achieved by combining the comparatively small frontal area of the vehicle with a slippery front profile, as is apparent from Figure 1, and as will now be discussed in more detail.

Referring then to Figure 1, it has already been mentioned that the vehicle includes a relatively short front overhang which is between 750mm to 850mm, and nominally 820mm in this embodiment. However, what is apparent in Figure 1 is that that the bonnet or hood cover 44 is also compact, and extends a short way rearward of the front wheel axis 8 before the windscreen 22 begins. Furthermore, the windscreen has a swept back appearance and as such has a low angle of inclination relative to the horizontal plane. In this embodiment, the horizontal distance between the front wheel axis and a rear or trailing edge 46 of the bonnet cover is approximately 55mm. However, it is envisaged that this dimension may be between 45mm to 65mm. Note that the distance is measured along the approximate centreline of the vehicle 2 and is indicated on Figure 1 as D8. So, this means that the rear edge of the bonnet cover 44 is located at a point approximately 875mm from the leading edge 40 of the vehicle, in the illustrated embodiment, although a dimension range of between 825mm and 925mm would be acceptable. The compact bonnet is combined with a shallow screen angle of between 60 degrees and 65 degrees, which is measured from the vertical plane to a tangent of a lower portion of the windscreen. More specifically, the screen angle may be between 62 and 65 degrees from the vertical plane. Expressed in another way, the screen angle may be between 25 and 30 degrees, preferably 28 degrees, when referenced to an imaginary horizontal plane. From there the windscreen gradually curves along an increasingly shallow trajectory until it reaches the forward roof line of the vehicle 2. The screen angle is illustrated on Figure 1 at A3. Note that it is at the trailing edge 46 of the bonnet cover 44 where the windscreen rises upwards and intersects the plane of the bonnet cover 44.

It is notable, too, that from a side profile the line of the windscreen merges smoothly with the roofline of the vehicle 2 and extends rearwards at a shallow reverse angle of inclination and terminates at the rear section 28 of the vehicle at a sharp rear edge 50, which is a benefit for aerodynamic efficiency as that profile encourages airflow separation at the rear of the vehicle thereby reducing drag. This is complimented by a relatively high waistline 51 that inclines at a shallow angle from the A-pillar of the vehicle towards the D-pillar over the tops of the door panels.

Appreciating the side profile of the vehicle in Figure 1, the reader will notice the rather raked appearance provided by the short front section 26, the reclined windscreen 22, and the relatively low roof line which slopes downward and rearward towards the back of the vehicle. These factors contribute to good aerodynamic characteristics for the vehicle, despite its size and passenger capacity, which may be up to seven people, at least. The position adopted by the passengers is configured to complement the relatively low-slung configuration of the vehicle, and as an example of this a row of front seats 52 is depicted in Figure 1.

Turning now to the front seats 52, it should be noted that the front seats 52 of the vehicle are situated in a relatively low position with respect to the floor of the vehicle which provides a useful amount of headroom for the driver. The front seats 52 are also represented by an H-point, which is labelled as H on Figure 1. As the skilled reader will appreciate, the H-point is the theoretical position of an occupant’s hip when they are seated in the vehicle, and represents the pivot point between the upper and lower portions of the body. In this embodiment, and as has been mentioned, the H-point is in a relatively low location in the vehicle. More specifically, in this embodiment, the H-point is at a height of about 750mm above the ground plane, as represented by dimension D9. More broadly, it is envisaged that an H-point height may have a nominal value of between 740mm and 760mm. However, this range may also be wider, particularly in embodiments equipped with adjustable suspension in which the range may be between 710mm and 790mm.

Significantly, the H-point in this embodiment is located at a vertical distance of about 450mm above the vehicle underside 30 (marked as D9' on Figure 1). Since the battery pack 4 is located beneath the vehicle cabin, between the vehicle underside 30 and the cabin floor, it will be appreciated that the passenger in the seat 52 sits low down in the vehicle which is atypical for such a large vehicle. This seating position may also provide the driver with a sensation that they are sitting low down or 'in' the vehicle which benefits drivability. Such a position is similar to the height at which a person would sit within a saloon or sedan like vehicle, having a relatively low ground clearance, so is not expected on a vehicle exemplified in the illustrated embodiment which has a much higher ground clearance, more typical of an SUV-style vehicle. Although not shown in Figure 1, the H-point is preferably located between 260mm and 300mm above the cabin floor of the vehicle.

The low H-point position avoids compromising the low roof height which would otherwise increase the vehicle frontal area thereby impacting on aerodynamic efficiency. As illustrated, the front row of seats are in a relatively inclined orientation whilst the long wheelbase of the vehicle 2 also allows the seating position of the front row to be located close to the mid-point of the vehicle, such factors being a benefit for passenger comfort since the front row passengers are more isolated from wheel vibrations. Importantly, this may be achieved without compromising on the space for the passengers in a second row of seats 53 since the long wheelbase enables the second row seating position to have premium levels of legroom. A third, optional, row of seats 54 is also provided. For instance it is envisaged that the second row 53 will be configured with between 810mm to around 1120mm between the H-point of the second row and the H-point of the first row 52, as indicated by the arrow labelled 55.

As an example, it is currently envisaged that the H-point may be selected to be at a horizontal position, relative to the leading edge of the windscreen and taken along the centreline of the vehicle, of about 1480mm. Note that this dimension value is a specific example but that others would also be possible, and it is currently envisaged that H-point positions between 1400mm and 1500mm would be acceptable. This dimension is indicated on Figure 1 as D10. It follows from the above dimensions that the horizontal distance between the H-point and the front wheel axis A1 may be between 1430mm and 1550mm, and in the illustrated embodiment is 1516mm.

Focusing now more specifically on Figure 2 and 3, a further striking aspect of the vehicle 2 is the configuration of the front and rear wheels 10,14 in the context of the overall shape and size of the vehicle. Conventionally, in the passenger vehicle context the dimension of wheels is measured in inches and it is typical for relatively large passenger vehicles to be provided with wheels whose rims are between 15 and 17 inches in diameter. Larger diameter wheel rims used to be the preserve of the aftermarket modification sector, although it is becoming more normal now to equip vehicles off the production line with 18 or 19 inch rims, and some large sports utility vehicles (SUV) may be equipped with 20 or even 21 inch rims.

When viewing Figure 2 and 3, however, it is noticeable that the wheels 10,14 have a large diameter, such that they are approximately 50% of the overall vehicle height. More specifically, the outer diameter of the wheels may be 845mm in this embodiment, although a diameter of between 800mm and 850mm is also acceptable. This dimension is indicated as D11 on Figure 3.

Whereas the overall diameter of the wheel 10 is nominally 845mm, in this embodiment, the diameter of the wheel rim 13 in this embodiment is 24 inches (approx. 610mm), although it is envisaged that a rim diameter of 23 inches (approx. 584mm) would also be acceptable. This dimension is indicated as D12 on Figure 3. It is envisaged that the wheels will be fabricated as once-piece cast or forged alloy wheel structure. However, two-piece or three-piece wheel structures are also acceptable. Although the diameter of the wheels is relatively large, it is also significant that the wheels are relatively narrow, and this can be appreciated by Figures 2 and 3 particularly. Here, the width of the tyres 11 is between 235mm and 255mm. This dimension is indicated as D13 on Figure 3. Also notable is the relatively large sidewall height or depth of the tyre compared to its section width, D13. Typically, larger wheels fitted to vehicles will tend to be fitted with tyres with a very low side profile. This is because lower profile tyres tend to exhibit improved cornering stiffness and mitigate the overall wheel diameter that is caused by increasing the rim diameter. In general, larger wheel sizes are generally thought to be undesirable in contemporary vehicles since they impact negatively on turning circle, wheel arch volume, and ride quality. However, in the vehicle of the invention, the tyre depth is envisaged to be approximately 50% of the section width of the tyre, for example between about 45% and 55%. In the illustrated embodiment, having a nominal wheel diameter or 845mm, and a rim diameter of 24 inches, the tyre depth is approximately 117mm, as is indicated as D14 on Figure 3. The relatively deep section tyre is a benefit since it absorbs higher frequency vibrations and increases the overall wheel diameter which benefits rolling resistance. By way of example, it is envisaged that a tyre having an outer diameter, section width and side wall depth may achieve a rolling resistance of between 4.5kg/t and 6kg/t, and it is believed that these values are significantly lower than rolling resistance of tyres used on tyres having a smaller outer diameter (for example 18 or 20 inch tyres) and a wider tyre section. The rolling resistance as expressed here is the rolling resistance coefficient, or C_{rr}, in units of kilograms per tonne, as would be understood by the skilled person. Such a wheel and tyre combination is not seen on contemporary vehicles fitted with radial tubeless tyres, or even airless tyres and, moreover, not on mass-produced vehicles that are manufactured in numbers in the order of tens of thousands of vehicles per year, at least.

The relatively tall and narrow wheels in the illustrated embodiment of the invention are beneficial in several further respects, as will now be explained.

Firstly, they are considered to contribute to the reduced frontal area of the vehicle, thereby reducing aerodynamic drag. Therefore, the use of large diameter wheels has a synergistic benefit since it provides advantages both for rolling resistance and the reduction in aerodynamic drag. At highway speeds, aerodynamic drag and rolling resistance are the two major contributors to the energy consumption of the vehicle. So, the vehicle of the invention achieves a significant improvement in this area which benefits its real-world range.

Significantly, the large diameter wheels are instrumental in the relative high ground clearance of the vehicle 2. As mentioned above, the ground clearance of the vehicle in the illustrated embodiment is about 300mm which is comparatively high as compared to saloon or sedan like vehicles, although the front row of passengers are supported within the vehicle in a more low-down, sedan-like seating position. This high ground clearance is made possible at least in part due to the large diameter wheels. The advantageous ground clearance combines with the long wheelbase of the vehicle to avoid compromising the breakover angle. As shown in Figure 1, the breakover angle ‘A4’ in the illustrated embodiment is approximately 21 degrees, and may be between 20 and 22 degrees.

Furthermore, without wishing to be bound by theory it is believed that the larger diameter and relatively narrow wheels will reduce the tendency to aquaplane in wet road conditions and will improve traction in snow. It is also envisaged that the large diameter wheels will transmit less road noise into the cabin of the vehicle and will benefit the stability of the vehicle on the move since the large diameter wheels are less affected by rough road surfaces and potholes.

Another benefit is that the larger rim diameter provides the opportunity to equip the vehicle with larger diameter brake discs. Larger diameter brake discs are believed to be beneficial since they allow a clamping load to be applied at a larger radius. So, the same brake torque can be generated by using a lower clamping load, which provides the opportunity to use more compact and lightweight brake pistons and calipers, thereby reducing unsprung mass. It is also believed to be better for brake cooling since the larger discs will expose a greater surface area to air flow around the wheel.

Finally, reference will be made to Figure 4. Here, the vehicle 2 depicted is the same as Figure 1, but the body proportions of the vehicle are illustrated with reference to wheel diameters of the vehicle. Accordingly, a dimension of one wheel diameter will be expressed as ‘1D’. Multiples and fractions of such diameters will be expressed with the same convention.

In terms of wheelbase, the distance between the front and rear wheels is approximately 3D, although the distance is slightly less than 3D in the illustrated embodiment. Also, the wheelbase dimension taken between the axle centres is approximately 4D. The overall length of the vehicle is approximately 6D. The front overhang is less than 0.5D, and approximately 0.3D. The rear overhang is less than 0.3D. The height of the vehicle waistline is approximately 1.5D, whereas the roofline height is approximately 2D. Notably the ground clearance is approximately 0.3D.

The skilled person would appreciate that the specific examples of the invention described above may be modified without departing from the inventive concept as defined by the claims.

For example, the illustrated embodiment is equipped with wing mirrors. However, embodiments are also envisaged in which the wing mirrors are omitted and a rear view from the vehicle is provided by a camera system instead. This benefits aerodynamic efficiency since wing mirrors present an obstruction to airflow past the vehicle and therefore are a source of drag. Omitting the wing mirrors thus provides the vehicle with a cleaner profile.

CLAIMS

1. An electric vehicle having a vehicle height of between 1600 mm and 1800 mm, a ground clearance of at least 260 mm, a wheelbase of between 3200 mm and 3350 mm, and a vehicle length less than 5100mm.

2. An electric vehicle as claimed in claim 1, wherein the vehicle length is between 4700 mm and 5000 mm.

3. An electric vehicle as claimed in claim 1 or 2, wherein the vehicle comprises a driver seat having a seat height of between 260 mm and 300 mm.

4. An electric vehicle as claimed in any one of the preceding claims, wherein the vertical distance between the driver H-point and the ground is at least 740 mm.

5. An electric vehicle as claimed in any one of the preceding claims, wherein the vehicle has a front overhang less than 850 mm.

6. An electric vehicle as claimed in any one of the preceding claims, wherein the vehicle comprises a passenger cabin and a battery pack positioned beneath the passenger cabin.

7. An electric vehicle as claimed in any one of the preceding claims, wherein the vehicle has breakover angle of at least 20 degrees.

8. An electric vehicle as claimed in any one of the preceding claims, wherein the vehicle has a front overhang less than 850 mm and a rear overhang less than 950 mm.

9. An electric vehicle as claimed in any one of the preceding claims, wherein the vehicle has an approach angle and a departure angle of at least 25 degrees.

10. An electric vehicle as claimed in any one of the preceding claims, wherein the vehicle comprises a windscreen inclined at an angle of between 25 and 30 degrees relative to the horizontal plane.

11. An electric vehicle as claimed in any one of the preceding claims, wherein the vehicle has a frontal area less than 2.7 square metres.

12. An electric vehicle as claimed in any one of the preceding claims, wherein the vertical distance between the roof of the vehicle and the underside of the vehicle is between 1340 mm and 1465 mm.

13. An electric vehicle as claimed in any one of the preceding claims, wherein the vehicle comprises a body and a windscreen, the horizontal distance between a leading edge of the body and a leading edge of the windscreen is less than 870 mm.

14. An electric vehicle as claimed in any one of the preceding claims, wherein the vertical distance between the underside of the vehicle and the roof of the vehicle is between 20% and 30% of the vehicle length.

15. An electric vehicle as claimed in any one of the preceding claims, wherein the vehicle comprises wheels having an outer diameter of between 45% and 55% of the vehicle height.

16. An electric vehicle as claimed in claim 15, wherein the wheels have a section width of between 27% and 32% of the outer diameter of the wheels.

17. An electric vehicle as claimed in claim 15 or 16, wherein the wheels have an outer diameter of between 800 mm and 850 mm, and a section width of between 235 mm and 255 mm.

18. An electric vehicle as claimed in any one of claims 15 to 17, wherein the wheels have a section height of between 80 mm and 135 mm.

19. An electric vehicle as claimed in any one of claims 15 to 18, wherein the vehicle has a vehicle width less than 1975 mm.

ABSTRACT

ELECTRIC VEHICLE

An electric vehicle having a vehicle height of between 1600 mm and 1800 mm, a ground clearance of at least 260 mm, a wheelbase of between 3200 mm and 3350 mm, and a vehicle length less than 5100mm.

(Figure 1)