Exterior Electric Hatchback Crossover Car Design with Strong, Vicious and Sharp Concept

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Abstract. Identity of design of an electric car is necessary to show electrical technology and added values for consumers. Design of electric cars today, in the meaning of appearance and image, are judged by consumers as weird and ugly compared to design of internal combustion engine (ICE) cars. The distinguished factor of electric car compared to ICE car is the technology that provides environment friendly and fuel energy crisis solution. Symbols of electric car can actually be build to be an interesting form and shape, such as smart, lightweight, efficient and clean. This research aims to design a small-medium electric car with 4-passenger car for young urban family consumer. The methods are consecutively: kind of car defining, 2D sketching, ergonomic or anthropometrical study, engineering and passenger package study, 3D styling and part design. The concept of form has adapted by keywords: strong, vicious, and sharp. Definition of ergonomic study based on Indonesian people with percentile of 5% women and 95% of men. Definition of engineering package based on Li-ion battery with size of 24 kWh placed under floor and single electric motor package placed on the front with front wheel system. The design result is a small medium crossover car with dimensions of wheelbase of 2500 mm, height of 1534 mm, front overhang of 858 mm and rear overhang of 723 mm. Design character of strong, vicious and sharp are transformed by small sharp headlamp and rear lamp; small grille with LED lines; smooth sculpting line on entire body; deep sculpting line on side body, firm and bold form of front and rear fender. The design outputs are 3D model of exterior, 3D model of body parts, 3D animation and physical scale model.

1. Introduction
This research aims to support development of the national electric car program in the year of 2013, whereas Institut Teknologi Sepuluh Nopember (ITS) is one of the five universities that taken part to it. The basic platform is small medium car that accommodates 4 passengers in urban area. The possible kind of this platform are sedan, hatchback, SUV(sport utility vehicle) and minibus (MPV -multi purpose vehicle) in the size of small-medium car. Sedan is a three-box passenger car consists of bonnet, passenger cabin and trunk with low-seat position (about 300 mm). Hatchback is a sedanbased two-box car, consists of bonnet and cabin with no box of trunk, because it is integrated with cabin. The trunk consists of a single door that are lift-up opened. SUV is a two-box car with high ground clearance (about 200 mm) with high-seat position. MPV is a single box or two-box car with highseat position (about 500 mm). Sedan and hatchback excel in comfort and appearance, whilst SUV and MPV excel in offroad capability and load capacity.
Specific design identity of electric cars in order to make differentiation to ICE car can enhance the needs and wants for consumer. By considering aspects of universal design so that electric car design can be
compete in the market. The purpose of this research is to design a 4-seat passenger electric car that suites to urban living for young family. According to that needs and wants, this research hypothesis is a stylish crossover hatchback that fits to accomodate activity of daily business and weekend holiday with semi-offroad ability to answer general infrastructure condition of Indonesia city.

![Figure 1. Basic Figure of Hatchback Car](image1.jpg)

2. Literature Review

2.1. The Best Research and Product
Design or styling of Range Rover Evoque is “a tasteful”, with excellent proportions without use of many lines and curves or folds on the body. The design makes Evoque seen as new image of urban crossover cars in the cities. Sporty mesh grill, futuristic layout and lamp shape, side air vents and floating roof. “Simplicity Design” used by the Range Rover is actually good proportion of basic form that can form a new image of SUV. Evoque design becomes inspiration of this research in styling concept that be build by good proportion from basic forms.

2.2. Proportion of Hatchback and Crossover
The body side proportion of hatchback and crossover car can be described belows.

![Figure 2. Car Types Classification](image2.jpg)

In H-Point, the 4-passenger electric car will be included in the Economic Car category, the largest group in the passenger car market. Hatchback Crossover is a car used in urban areas with average long size of 3400 mm.

2.3. Interior Environment Study
Interior environment dimension of car bases on passenger seat position (H-Point). The study of seat position can be described as follows.
Determining size of car must consider size of the passengers inside. Design experts stated that the formation of the car starts from the inside out. It aims to make passengers comfort and safe in the cabin. For most types of passenger cars, the H-Point is relatively low to facilitate access in and out of the car and provide a low center of gravitation. In addition to human anthropometry, there are several important points in determining hardpoint because interior is the most important factor in determining the exterior dimensions of the car as it is directly related to the user's comfort factor.
Figure 3. Various Driver height from ground and postures

Figure 4. Visibility through rear window

Figure 5. Rear Seat folding mechanism

Figure 6. Terms of installation of a car windshield
2.4. Engineering Packaging Study
In determining electrical components and layouts for electric drive, different treatment with the machine, in general, is required. Supporting components are also different from ICE cars.

![Figure 7. Specification of the electric motor](image)

The motor used is usually smaller in size but the fuel storage or motor battery is larger so that the shape of the car becomes longer. Therefore, the battery is usually placed under the floor.

![Figure 8. Layout type of propulsion motors in electric cars.](image)

3. Research Methodology
The research process can be described belows:

a. Product planning: analyzing the problems of the product on the market, including the needs and wants of consumers, competitors, as well as ongoing trends. This study defines a car kind by MSCA (market survey and competitor analysis) that obtained a car that suited to the variable of: comfort, young look/appearance and semi-offroad capability. MSCA result is a combination of hatchback and SUV with small-medium size. This car is then defined as Hatchback Crossover Car. Hatchback represents good appearance and comfort, whilst SUV represents semi-offroad capability and load capacity. The seat position is defined as high-low seat position (about 400 mm).

b. Benchmarking of size and proportion to existing products with similar attributes to define golden proportions.

c. Ergonomic study: determining consumers or user needs by analyzing their activity and dimension in order to realize comfort and safety. The result is configuration of passenger and engineering package with each dimension.

d. Design ideation: developing shape and form of overall body. The result is facade design and 3D appearance that transforms the concept of strong, vicious and sharp.

e. Final design: developing design into 3D digital geometry for overall exterior body and main single
parts. The output is 3D digital geometry which can run CNC machine to make positive model and mold for production process

3.1. Benchmarking Study
- Objectives: determine base and dimensions of car that will be used as platform of the electric car design
- Variable: interior space, number of seats, layout, volume
- Sample: Mini Countryman, Nissan Juke and Suzuki SX-4
- Method: observation and experiment
- Result:
  - Dimension (L/H/W in mm): 3840-3860/1680-1720/1480-1520.
  - Best proportion: Countryman; best strong image: Nissan Juke; best sharp image: Juke; best vicious image: SX-4

3.2. Consumers Behaviour Analysis
- The 25-30 years old, with energetic and attractive soul
- Young family (3-4 people), a new family with 1-2 kids.
- Living in urban areas.
- High mobility in daily activity.
- Fun behavior in business and family communication.
- Smart attitude in technology usage.
- Friendly spirit to the environment.

3.3. Ergonomic Study of Passenger Package
By combining data used in midsize car and electric car, interior dimensions which have been applied to human anthropometry of 95 percentile of men and 5 percentile of women can be determined as follows.

Figure 9. Hardpoint of the electric hatchback crossover car as the research result

Passenger height of the 95 percentile men is similar to 187.5 cm and the 5 percentile women is similar to 163.6 cm. The men have upward vision angle of 18° and downward vision angle of 11°, whereas the women have upward vision angle of 32° and downward vision angle of 7°.
Figure 10. Anthropometric study result of 95 percentile-men and 5 percentile-women

3.4. Ergonomic Study of Engineering Package
Main engineering elements that must be considered in design are battery, motor, converter and drive train components. The result of this study can be described as follows.

Figure 11. Engineering package result of the electric crossover-hatchback car

Figure 12. The kWh battery that will be installed under the floor of the electric crossover-hatchback car.

Battery and electric motors that applied in this research are adapted from Nissan Leaf electric car, i.e: lithium-ion battery 24kWh, with 48 lithium-ion per module and electric motor of 80 kw AC motor, 187 lb-ft and 107 horsepower. The result researches above then developed into basic dimension approaches that can be described at table belows.
Table 1. Basic Dimension

| Element          | Dimension                   |
|------------------|-----------------------------|
| Overall L/W/H    | 3850 / 1700 / 1500 mm       |
| Wheelbase        | 2450 mm                     |
| Wheel Dimension  | 185 mm, 55 mm, 16’ up to    |
|                  | 215 mm, 55 mm, 18’          |
| Front/rear tread | 1480 / 1485 mm              |
| Ground Clearance | 190 mm                      |

Engineering aspects that can be implemented to the design, research by electric and mechanic team can be described at table belows.

Table 2. General Engineering Specification

| Element            | Specification                                      |
|--------------------|---------------------------------------------------|
| Motor              | 80 kW AC synchronous electric motor, 107 hp        |
| Battery            | 24 kWh lithium-ion (Li-ion)                        |
| System Charge      | 6.6 kW Onboard Charger                            |
| Distance Cruise    | 160 km                                            |
| Structure System   | Tubular frame                                     |
| Body Structure     | Monocoque                                         |
| Suspension System  | Front: McPherson Strut + Coil Spring Rear:        |
|                    | Torsion Beam + Coil Spring                        |
| Gross Weight       | 1480 kg                                           |
| Curb Weight        | 980 kg                                            |

Integration of ergonomics study and engineering package assumption produces general lay-out of electric car design. This lay-out provides ergonomic space for 4 passengers with optimum space at human body, leg and head room at any gestures. This lay-out also provides suitable arrangement of electric equipment. Design of body structure can also be developed clearly caused of this definitive lay-out.

4. Design

4.1. Styling Concept
The styling concept is determined from the needs and wants of strong, vicious and sharp character. These keywords than develop into the image board that represents to it, as described as follows.

Figure 13. Image board of products that express strong, vicious and sharp images that represent the target consumer
The image board then develop into hand sketches of perspectives below.

![Figure 14. Hand Sketch of The Overall Car Exterior](image)

From the image board above, sketches of form and line represent strong by firm constant line harmony, while vicious is obtained from rising line from one side and sharp is shown by lines that has pointed to form angle.

4.2. The 3D Digital Modelling
The 3D digital modeling process is developed from hand sketches by graphic computer. The result can be described as follows.

![Figure 15. Surfacing Process in 3D Digital Modeling](image)

![Figure 16. The 3D digital rendering of front and rear views](image)
Figure 17. The 3D digital rendering of side and top views.

Figure 18. The 3D digital rendering of ¾ front-side and ¾ rear-side perspective view
4.3. The 3D Digital Modelling of Body Parts

The next step of this research is to explode the entire exterior model into body parts. The main body parts are structure elements, i.e.: side panels (left and right), roof and floor. The second main ones are filler elements, i.e: doors (sides and rear), bumpers (front and rear), engine hood, windshield and all glass windows. All design of body parts can be figured as follows.

In order into production phase, each body part must be run into single part production required, such as: mold, press machine, cutting machine, finishing machine and mechanicalelectrical support element. The main body parts (side panels, floor and roof) must be arranged in order to form basic shape. After that, each secondary main body part and other mechanical-elecrical supported part can be assembled following the production line and procedure. This research results.

![Image](image_url)

**Figure 19.** The 3D digital geometry of main single parts of exterior

5. Conclusion

From previously design, it can be concluded that:

1) The style of strong, vicious and sharp can be obtained by:
   - Strong: proportion consists of wheelbase of 2500 mm, height of 1534 mm, front overhang of 858 mm and back overhang of 723. This proportion figures sporty and muscle image.
   - Vicious: short bonnet, bigger windshield and sharp headlamp from front to side with LED figure as 6 vicious factor. Small and lines of grill form also enhance the image of vicious.
   - Sharp: combination of smooth and sharp body sculpting and carving figure sharp concept. Form of head lamp and rear lamp that adapted from blade shape also sthengthen the sharp image

2) Styling character that has been obtained from determining line characteristics:
   - Strong: line arrangement that forms firm, dynamic and bold.
   - Vicious: curve line that raising from bottom to top.
   - Sharp: line s that form small pointed angle.

3) Dimensions of the battery under the passenger seat can provide a good ergonomics level for the interior package for 2 adults (height 187.5 cm) in front and 2 children in rear seat.

4) The 3D digital geometry of overall exterior body roles as a visualization of real appearance of design of hatchback crossover electric car that shows its styling, (form, dimension, line, surface and color).
5) The 3D digital geometry of single part body roles as a platform for manufacturing production process that are ready to apply to make positive model and mold by CNC machine.

6) This research results 16 body parts in 3D digital geometry, i.e: 2 side panels (left and right), roof, floor, 3 doors (L, R and rear), 2 bumpers (front and rear), engine hood, grill, 2 front fenders (L and R), 2 head lamps (L and R) and 2 rear lamps (L and R).

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