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The Combination of Extendable EV Power Brace and Axial-change Power Set

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Abstract

There are already many companies try to launch the new motor type, axial-change power set ,the only difference in appearance of different power motors is in axial length, and the other section, like radial length, and all locking points remain the same size, Therefore, if you need to exchange a different output power motor, the body structure which needs to be changed can be significantly reduced. we got the idea of design extended electric vehicle power brace.

At design stage, using the ANSYS to assess the strength and rigidity。After passing the verifying，output the design prototype by CNC processing and equip it with real vehicle.

Keywords: car, DC motor, motor, powertrain

1 Extendable EV Power Brace and Axial-change Power Set

In traditional ICE vehicles, the same kind of body will often carry more than one engine as a sell, but because of the complex structure of the engine, and the great internal pressure and high temperature, the numbers of components are large, the weight of engine and transmission may be over than 200 kg. In apparent, the complexity of weight and shape is much higher than the electric motors, so it needs to design different engine brackets to fit with different engine. The elasticity of power system replacement forms a big problem, but it can be solved easily in electric vehicle.

1.1 Axial-change Power Set

Unlike the internal combustion engine is powered by high pressure explosion, the vibrations on the motor body is relatively negligible relative to the internal combustion engine, and fewer parts, so the size on relative to the engine can be more smaller, and orderly.

There already many companies have had introduced new types of motor which the only change in different output power motors is the length of the rotation axis, and the radial shape, the junction points of the motor would be keep the same size, and we called it "**Axial-change Power Set**", shown in Figure 1. Therefore many of the component sets can be shared to the series, and it would be helpful to reduce the production cost, and if we need to switch a different output power motor, the necessary changes in body structure can be significantly reduced. Because of the idea, we design the "**Extendable EV Power Brace"**, to reduce the production cost and increase the elasticity of replacement.

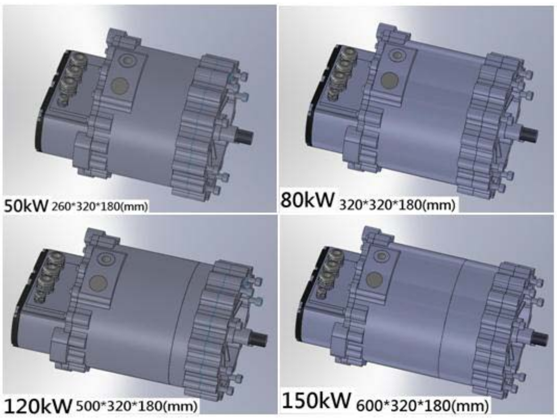

Figure 1: Contribute to the differences between different only in the axial length of the motor

2 The structure of Extendable EV Power Brace

First, define the components of the power system, shown in figure 2, the necessary components for the elasticity of replacement are: the left and right extension bracket; the reducer side bracket; the reducer low bracket; the motor side bracket; the combined bracket; top rubber absorber; bottom rubber absorber.

The introduction of the following:

(1) Top rubber absorber and bottom rubber absorber: In the traditional ICE vehicles, because of the engine repeated explosions and compression, we need engine mounts to block the vibration of engine to transfer to the whole car body, to make the passenger feel comfortable. But in EV, the vibrations of motors are very small, so the functions of the rubber absorber may be focused to block the vibration from the uneven road, to keep the motor could output the smooth power. We chose aluminum alloy material, it can give consideration to high strength and light weight. (Figure 3, Figure 4)

(2) Left and right extension bracket and the reducer low bracket: these are the most important roles in the power elastic replacement concept. As described in the preamble, there have had some companies to design and manufacture motors moving in for the "different output electric motor only have difference in the vertical length ". So in the future, for a "just changed in the vertical length" of the motor series model, we only need to be replaced with the left and right extension bracket and the reducer low bracket for different motor longitudinal length.

(3) The reducer side bracket, the motor side bracket and the combined bracket: The reducer side bracket links left extension bracket and reducer; the motor side bracket links right extension bracket and motor; the combined bracket links motor and reducer. Based on the "different output electric motor only have difference in the vertical length "concept, different output power of motors do not change the lock point, so these three bracket are versatile components.

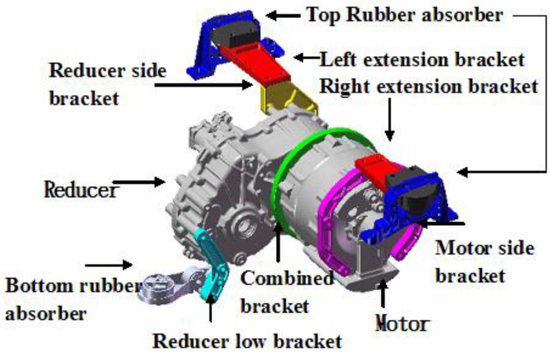

Figure 2: The definition of power system components

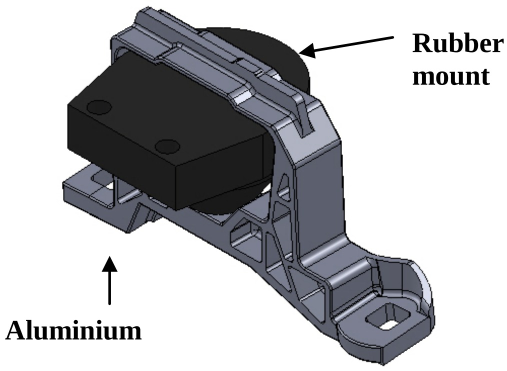

Figure 3: Top Rubber absorber

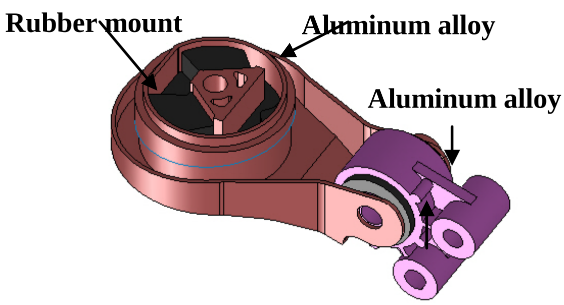

Figure 4: Low Rubber absorber

3 The analysis Extendable EV Power Brace

Electric cars running on the road, due to transmission, acceleration, braking and steering, etc., put the load from different direction on the power system, so the power system bracket must have sufficient rigidity frame and strength to face the load from any situation and keep the power system stable. Therefore, using the computer-aided engineering to simulate the strength and rigidity of model is the key of first step.

In this study, using CAE software HyperMesh and ANSYS Mechanical to establish the finite element (Finite Element, FE) model, shown in Figure 5. The motor and reducer are combined into a physical interface to simplify the structure, constructed by eight-node hexahedral elements Solid45; top and low rubber absorber simulated by two-node spring elements COMBLIN39; Left and right extension bracket, Reducer side bracket, Reducer side bracket and motor side brackets were constructed by Solid45, too. In screw holes, using Solid45 fill the hole, and connected the part node to node. In order to make the simulation to be more closer to reality, we apply a layer of elemental TARGE170 (or CONTA174) to all the contact surface of all parts, and to simulate the contact between the object.

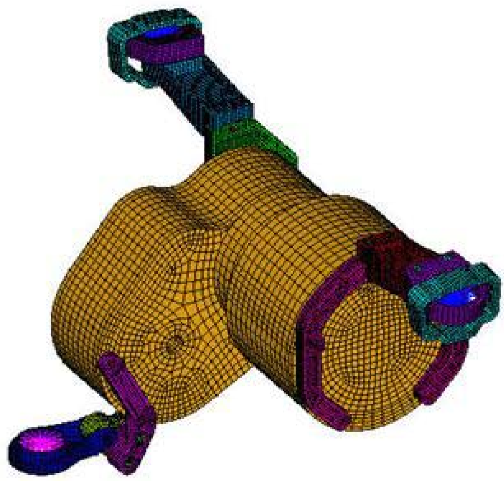

Figure 5: Finite element model of power system

First, define the position of power system's center of gravity, according to the data from the manufacturer, to estimate the position of power system's center of gravity, as marked in Figure 6. Refer to the actual power system locking point, binding the top and low rubber absorber. To simulate the power system which under the situation as below: +981 N-m,-981N-m, X direction +3 G, X direction-3G, Y direction +3 G, Y direction-3G, Z direction +3 G, Z direction-3G, X direction +4 G, X direction - 4G, Y direction of +4 G, Y direction-4G, Z direction and Z direction of +4 G-4G, as detailed in Table 1.

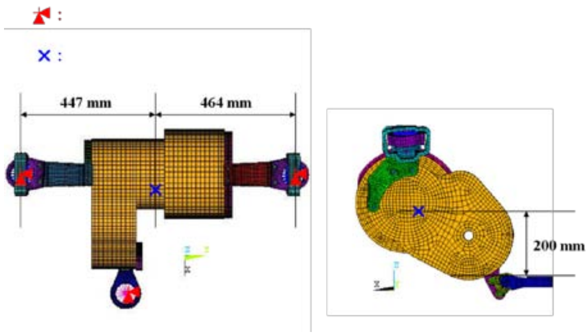

Figure 6: Binding and the centre of gravity

Table 1: Illustration of the load condition

Load condition	illustration
+981N-m	In the transmission process, the power system output torque acting on the wheel by the shaft, and the power system to bear the output torque with the same size and opposite reaction, the maximum motor output torque is 150N-m, gear reduction ratio is 6.54. Therefore, the maximum output torque for the power system is 150N-m × 6.54 = 981N-m. When simulated +981 N-m load conditions, we will applied +981 N-m of torque to the output shaft hole FE model nodes, to simulate the maximum torque on the power system during the transmission process.
-981N-m	If the car goes forward, the motor forward torque acting on the power system would be +981N-m; in the other hand, the car goes back, the motor reverse torque acting on the power system would be -981N-m.

X direction +3G	Definition the direction from front to rear is the X direction, and the weight of power system is 100KG. By the equivalent load 3G in X direction, the FE model is applied to the center of gravity position of the nodes in the X direction +2943 N loads, to simulate power system receiving 3G acceleration in X direction.
X direction -3G	When the car goes ahead and breaks the car suddenly, the acceleration in -X direction would apply to the power system. Setting the weight of the power system is 100KG. By the equivalent load -3G in X direction, the FE model is applied to the center of gravity position of the nodes in the X direction -2943 N load, to simulate power system receiving- 3G acceleration in X direction.
Y direction +3G	Definition the direction from left to right side of car is Y direction, and when the car turns left, the acceleration in Y direction would apply the equivalent load 3G to the power system. Setting the weight of the power system is 100KG. By the equivalent load 3G in Y direction, the FE model is applied to the center of gravity position of the nodes in the Y direction 2943 N load, to simulate power system receiving 3G acceleration in Y direction.
Y direction -3G	When the car turns right, the acceleration in Y direction would apply the equivalent load -3G to the power system. Setting the weight of the power system is 100KG. By the equivalent load -3G in Y direction, the FE model is applied to the center of gravity position of the nodes in the Y direction -2943 N loads, to simulate power system receiving -3G acceleration in Y direction.
Z direction 3G	Definition the direction from bottom to top of car is Z direction, and when the car run over the bulge, the acceleration in Z direction would apply the equivalent load 3G to the power system. Setting the weight of the power system is 100KG. By the equivalent load 3G in Z direction, the FE model is applied to the center of gravity position of the nodes in the Z direction 2943 N load, to simulate power system receiving 3G acceleration in Z direction.
Z direction -3G	When the car goes through the hole, the acceleration in Z direction would apply the equivalent load -3G to the power system. Setting the weight of the power system is 100KG. By the equivalent load -3G in Z direction, the FE model is applied to the center of gravity position of the nodes in the Z direction -2943 N

	loads, to simulate power system receiving -3G acceleration in Z direction.
X direction +4G	Definition the direction from front to rear is the X direction, and the weight of power system is 100KG. By the equivalent load 3G in X direction, the FE model is applied to the center of gravity position of the nodes in the X direction +3924 N loads, to simulate power system receiving 3G acceleration in X direction.
X direction -4G	When the car goes ahead and breaks the car suddenly, the acceleration in -X direction would apply to the power system. Setting the weight of the power system is 100KG. By the equivalent load -3G in X direction, the FE model is applied to the center of gravity position of the nodes in the X direction -3924 N load, to simulate power system receiving- 3G acceleration in X direction.
Y direction +4G	Definition the direction from left to right side of car is Y direction, and when the car turns left, the acceleration in Y direction would apply the equivalent load 3G to the power system. Setting the weight of the power system is 100KG. By the equivalent load 3G in Y direction, the FE model is applied to the center of gravity position of the nodes in the Y direction 3924 N

	load, to simulate power system receiving 3G acceleration in Y direction.
Y direction -4G	When the car turns right, the acceleration in Y direction would apply the equivalent load -3G to the power system. Setting the weight of the power system is 100KG. By the equivalent load -3G in Y direction, the FE model is applied to the center of gravity position of the nodes in the Y direction -3924 N loads, to simulate power system receiving -3G acceleration in Y direction.
Z direction +4G	Definition the direction from bottom to top of car is Z direction, and when the car run over the bulge, the acceleration in Z direction would apply the equivalent load 3G to the power system. Setting the weight of the power system is 100KG. By the equivalent load 3G in Z direction, the FE model is applied to the center of gravity position of the nodes in the Z direction 3924 N load, to simulate power system receiving 3G acceleration in Z direction.
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	model is applied to the center of gravity position of the nodes in the Z direction -3924 N loads, to simulate power system receiving -3G acceleration in Z direction.

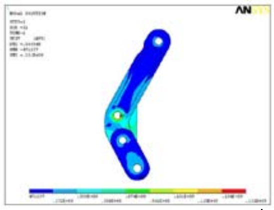
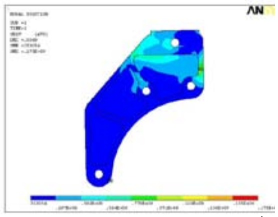
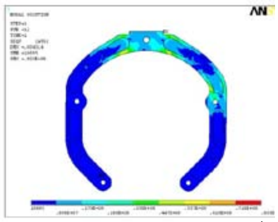
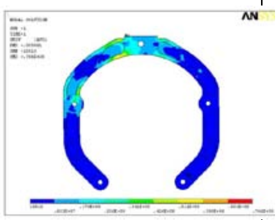
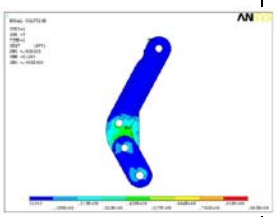
4 Analysis result

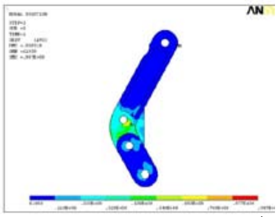
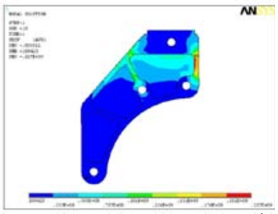
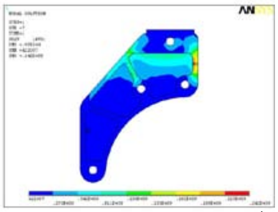
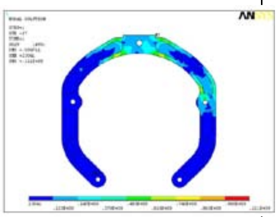
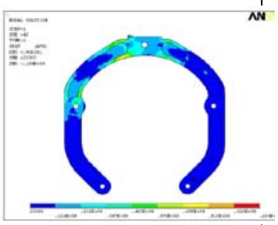
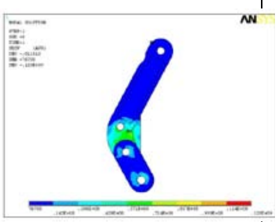
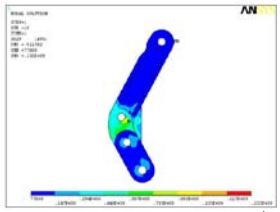
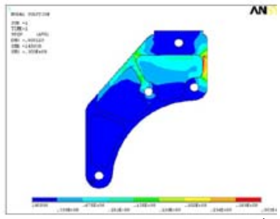
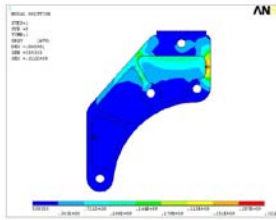
To arrange the simulation results in Table 2, and the stress mean Von Mises stress, maximum stress mean the maximum Von Mises stress of each part. Seen from table2, when the power system receives the loads of X direction, the highest stress is in the motor side bracket; when the power system receives the loads of Y direction, the highest stress is in the reduce low bracket; when the power system receives the loads of Z direction, the highest stress is in the reducer side bracket

When power system receive ± 981N-m torque load and ±3G force in all directions, each stress in all brackets are less than the yield strength (AA6061-T6 of the yield strength of 270MPa), it means that the brackets can make a stable support for the motor and reducer in such load situations. When the power system receive ± 4G in Z direction, the stress in reducer side bracket exceeds the material yield strength, even more than the material ultimate strength (AA6061-T6 of the ultimate strength of 310MPa) , in such loads, the reducer side bracket will occur to have a permanent plastic deformation, and even fracture.

Collate the results, we knew the loads of X direction and Y direction should not exceed ± 4G, and the load of Z direction should not exceed ± 3G, in order to avoid the failure situation.

Table 2: The maximum stress value of parts under various load conditions

Load condition	**Part name**	**Max. stress**	**Stress distribution**
+981N-m	**Reducer low bracket**	**151 MPa**	
-981N-m	**Reducer side bracket**	**175 MPa**	
X direction 3G	**Motor side bracket**	**80.5 MPa**	
X direction -3G	**Motor side bracket**	**76.6 MPa**	
X direction 3G	**Reducer low bracket**	**96.5 MPa**	

Y direction -3G	**Reducer low bracket**	**98.7 MPa**	
Z direction 3G	**Reducer side bracket**	**227 MPa**	
Z direction -3G	**Reducer side bracket**	**242 MPa**	
X direction 4G	**Motor side bracket**	**111 MPa**	
X direction -4G	**Motor side bracket**	**104 MPa**	
Y direction 4G	**Reducer low bracket**	**128 MPa**	
Y direction -4G	**Reducer low bracket**	**132 MPa**	
Z direction 4G	**Reducer side bracket**	**303 MPa**	
Z direction -4G	**Reducer side bracket**	**322 MPa**	

After passing the analysis, create a real prototype to equip with the demo car. (Figure 7 ~ Figure 10).

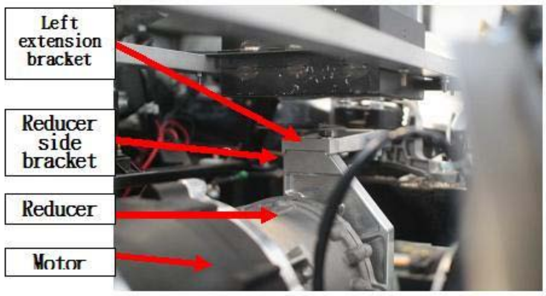


Figure 7: The Combination of Extendable EV Power Brace and Axial-change Power Set (1)

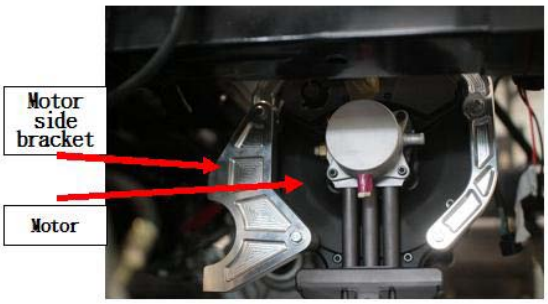


Figure 8: The Combination of Extendable EV Power Brace and Axial-change Power Set(2)

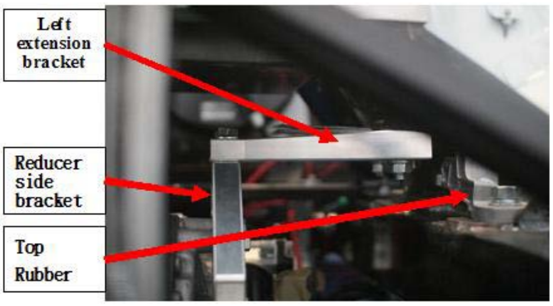


Figure 9: The Combination of Extendable EV Power Brace and Axial-change Power Set(3)

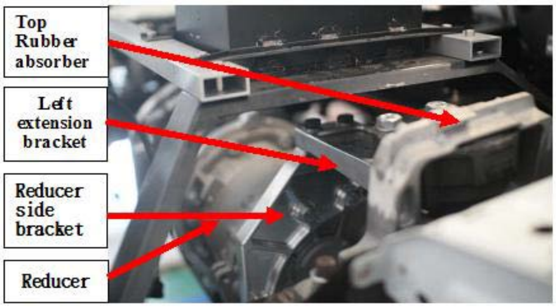


Figure 10: The Combination of Extendable EV Power Brace and Axial-change Power Set(4)

5 Conclusion

Preliminary results from the simulation, define the power system can withstand the maximum load, the load of X direction and Y direction should not exceed ± 4G, the load of Z direction should not exceed ± 3G, in order to avoid the bracket failure situation.

But in actual electric vehicles operation, the power system will not only withstand the load in one direction, usually receive the combined loads from more than two directions. In the future, using the motion simulation software (such as ADAMS) to test and verify the power system loading condition in accelerate, braking and cornering, etc, and would be able to do a more accurate assessment.

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