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Research on Ergonomics Design of New Energy Passenger Cars Based on RAMSIS Software

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Abstract: As consumers' demands for car performance and driving experience gradually increase, the ergonomics design of vehicles is becoming increasingly important. A good ergonomics design scheme has a significant impact on improving the comfort, ease of operation, and driving safety of drivers and passengers. RAMSIS software as a professional ergonomics design application software has friendly operating interface, comprehensive human body model data, rich verification projects and practical functional modules and that has the characteristics of simple operation, intuitive and convenient. So it has incomparable advantages in designing and verifying the rationality of ergonomics solutions compared to other software. This article is based on the development project of a new energy passenger car. Ergonomics design and optimization were carried out in the RAMSIS software environment. It has proven that many problems were discovered and solved by using RAMSIS software during the project advancement process in practice. At the same time, experience was accumulated for similar vehicle development projects.

Keywords: RAMSIS; New Energy; Passenger Cars; Ergonomics Design

1. Introduction

A vehicle is a human centered product that needs to focus on how to better meet the needs of drivers and passengers, in order to create a comfortable and reliable driving environment and seating space. Therefore, whether it is the exterior design, interior space layout, safety system, or component structure design of vehicle, the ergonomics needs to be considered. Ergonomics is a highly comprehensive emerging interdisciplinary field that studies the laws of the relationships and interactions between humans, machines and the environment based on human physiological and psychological characteristics [1].For passenger cars, the research on ergonomics mainly refers to the study of the internal layout of the car, such as the steering wheel, operating lever, accelerator pedal, clutch pedal, brake pedal, seats and etc., which need to meet the comfort and convenience needs of driver's operation and ride [2].Automotive ergonomics design involves multiple disciplines such as automotive design theory, ergonomics, and aesthetics [3].

Early ergonomics design was mainly carried out in a two-dimensional environment. In the past decade, due to the emergence of RAMSIS software, ergonomics design in a three-dimensional environment has become very common. The application of RAMSIS makes ergonomics design more intuitive and convenient, while complementing traditional two-dimensional design, leveraging their respective advantages, and accelerating product development.

In the automotive industry, over 75% of global car manufacturers use RAMSIS, which has become an industry recognized software widely used for automotive ergonomics analysis. This article takes a new energy passenger car development project as an example to introduce how to achieve ergonomics design and optimization through RAMSIS, and discover and solve many problems. This case is conducted using the V5-1-4-100-R26NET2012 version of RAMSIS software.

2. Key Points of Vehicle Ergonomics

For studying the ergonomics of vehicle, setting the driver's sitting posture and cockpit layout environment is an important task in vehicle development, because it involves the internal space layout, seat design, dashboard layout and the setting of control levers/buttons which are

closely related to the driving experience. RAMSIS can be used to design and optimize the above points, and overcome the shortcomings of the existing SAE J826 template human body, further improving the ergonomics quality of vehicles [4].

The main functions of RAMSIS software include defining human body models, defining human body postures, analyzing hand extension interfaces, defining seat belts, analyzing field of view and analyzing human comfort and etc. The various functional modules are shown in **Figure 1**. The human body model module has functions such as setting the percentile of the human body, selecting the age group, gender, country of origin, referencing the year of the human body, and body shape which can meet the changes in human body size in different situations. The human body posture module can adjust the joints of the human body based on the set human body model, so as to reach the comfort range of the relevant joint angles thereby meeting the requirements of human driving comfort. The hand extension interface analysis module can automatically generate a hand operable envelope based on the position and posture of the human body model which can be used for verifying the scheme of control components. Defining the seat belt module can simulate and analyze the comfort of seat belts in the wearing state of the human body based on the human body model which is very intuitive and effective for analyzing the comfort of seat belt schemes. The field of view analysis module can verify the field of view based on the position and posture of the human body which is also very intuitive and easy to operate. The human comfort analysis module can score the design scheme of human posture in multiple dimensions to form a comprehensive scoring table. Based on this score, the rationality of the human posture design scheme can be evaluated and the problem points that need to be optimized can be identified.

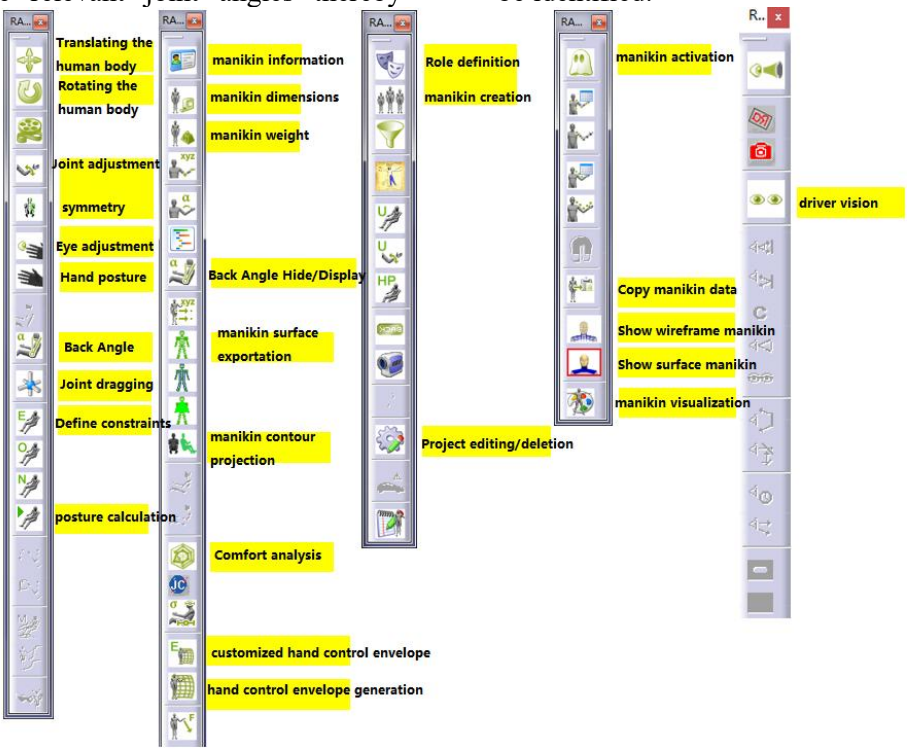


Figure 1. Main Functional Modules of RAMSIS

3. Ergonomics Design Based on RAMSIS

In the ergonomics design of this new energy passenger car model, the two-dimensional layout of the human body inside a new energy passenger car has been completed and verified to meet the design requirements, as shown in **Figure 2**. However, two-dimensional diagrams cannot effectively verify certain schemes in three-dimensional environments, such as the steering wheel, dashboard, auxiliary dashboard, tweeters, and seat belts around the human body. These schemes involve the space around the human body, the performance of components, and the comfort of use. In this case, RAMSIS software is needed for further verification.

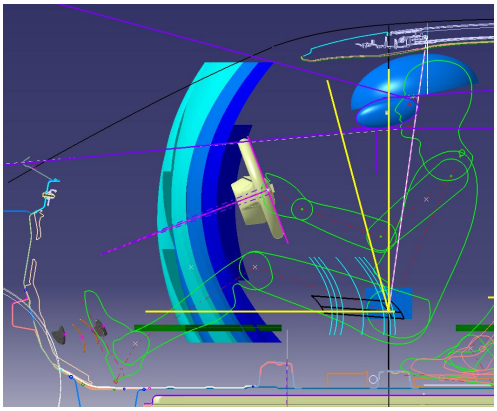


Figure 2. Two Dimensional Human Body Layout

3.1 Define Human Body Model

The ergonomics always revolves around the human body as the fundamental object, therefore defining the human body model is the starting point for all ergonomics design schemes. The size of the human body model defined by RAMSIS needs to be consistent or close to the size of the human body in the two-dimensional layout diagram.

The original human body data of RAMSIS was established based on an extensive anthropometric survey of Germans. Therefore, the obtained body shape results can be applied to all Central European countries (with only minor constraints in calculations) and even to North America (the United States and Canada) [5].

In the ergonomics design of this new energy passenger car model, we first use the "Creat Role" command to confirm the "H-point", "posture Model", "prepositioning point" in the "RAMSIS NG Role Definition" dialog box, all others are default, and finally click "confirm" to create the human body, as shown in **Figure 3**.

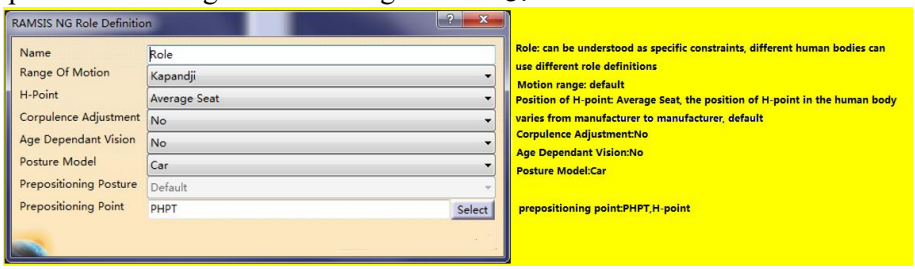


Figure 3. Define Human Body Model

Using the "Creat Manikin" command, set gender, country, age, reference year, size, obesity, proportion, shoe model, and hair model in the "RAMSIS NG Create Manikin" dialog box, as shown in **Figure 4**. The hair model setting does not affect human height.

In actual vehicle development projects, the human body is generally designed and analyzed according to three types of human bodies: 5% (female body), 50%, and 95%, as shown in **Figure 5**. Therefore, the following corresponding settings can be made in RAMSIS.5% human body can be set as Chinese female, aged 36-55, referring to the human body in 1988 year, with a medium human body size (human body height of 1563mm).50% of the human body can be set as Chinese males, aged 26-35 years old, with reference to the human body in 2030 year, and a medium human body size (with a height of 1724mm).95% of the human body can be set as a German male, aged 30-49 years old, with reference to the human body in 2010 year and a high body size (body height of 1888mm). If the developed vehicle model is mainly targeted at the Chinese market, the human body size can be set according to the age group of "GB/T10000 Human dimensions of Chinese adults" (2023 version) [6].

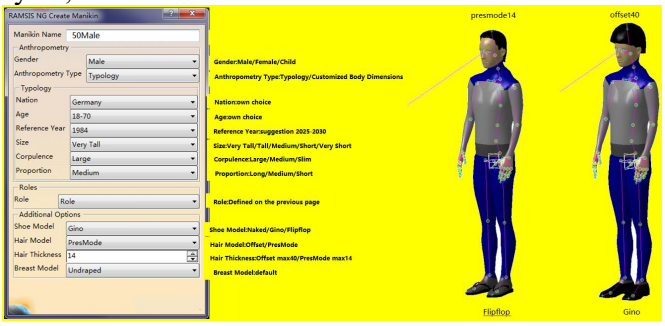


Figure 4. Set Human Body Parameters

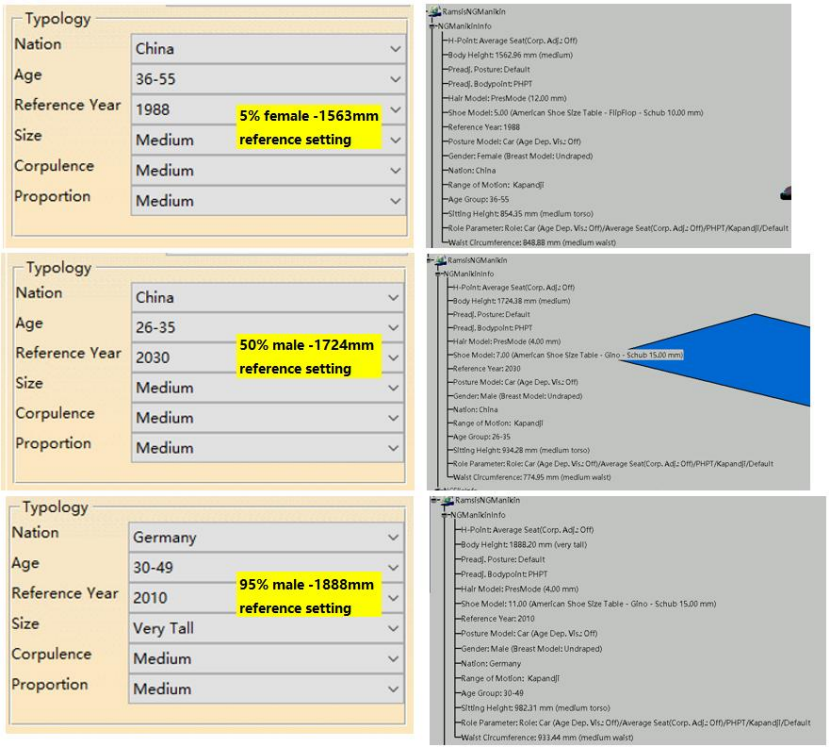


Figure 5. Set Three Types Of Human Body 5%, 50% and 95%

3.2 Define Human Posture

Defining human posture is a crucial aspect of ergonomics design, which directly affects the quality of ergonomics solutions. In our automotive project, the main components that affect driving posture include the steering wheel, seats, pedals and etc [7]. Based on the key hard point parameters generated in the two-dimensional human body layout diagram (such as the straight line and plane where the heel point is located, the center line of the accelerator pedal, the left and right endpoints of the steering wheel, the rest pedal surface, and the seat stroke, i.e. the key points, lines, and surfaces), these hard point parameters are extracted and combined with the pre-set human body model, ergonomics analysis can be carried out in the RAMSIS environment, as shown in **Figure 6**.

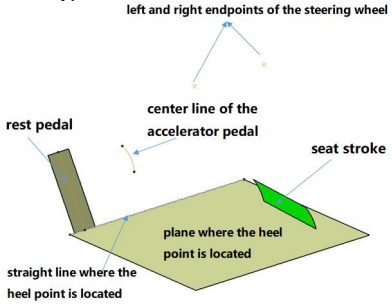


Figure 6. Extraction of Human Hard Point Parameters

Use the “RAMSIS NG Define Constraint” command, select “TARGET” in “Constraint Type”, select human skin points in “Manikin Comp”, and select the constrained faces, points, and lines in the “Env. Object”, click “OK”, and a red line will appear for the human skin points and constraints. Repeat the above operation to complete the constraints on the hand, H-point, foot, heel point and etc.

Select “Pelvis Rotation” in “Constraint Type”, check “Tilt Sideways”, and click "Apply" to prevent the human body from tilting left or right; Select “Torso Angle” in “Constraint Type”, enter the backrest angle value in “Fixed Angle”, click “Apply” to set the backrest angle, as shown in **Figure 7**.The backrest angle, shoulder angle, elbow angle, hip angle, knee angle and hand angle must all meet the recommended angle values of SAE J826 regulations [8].

Using the “RAMSIS NG Posture Calculation” command, click “Start” to simulate and complete the definition of human posture.

After the definition of human body posture is completed, the “Calculate the Skin Geometry” (Export of human body shape) command can be used to generate a three-dimensional human body surface, as shown in **Figure 8**, and then ergonomics analysis and optimization can be carried out.

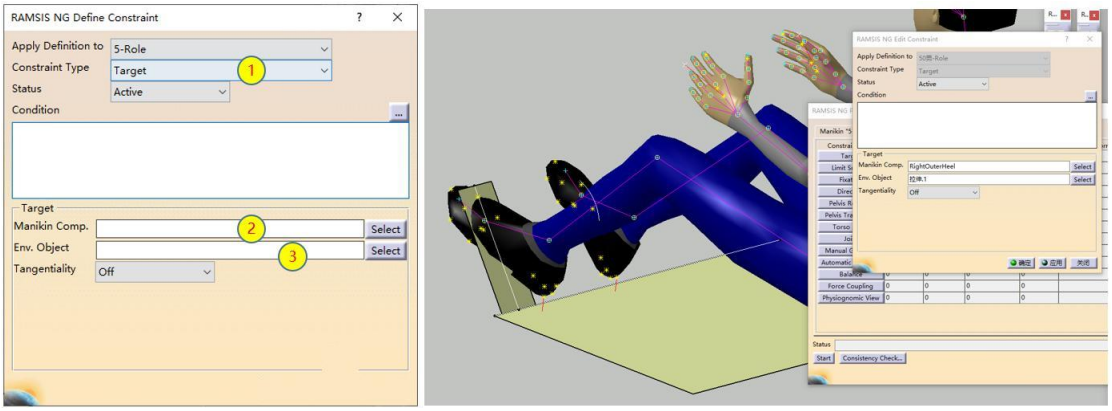


Figure 7. Establish Constraints

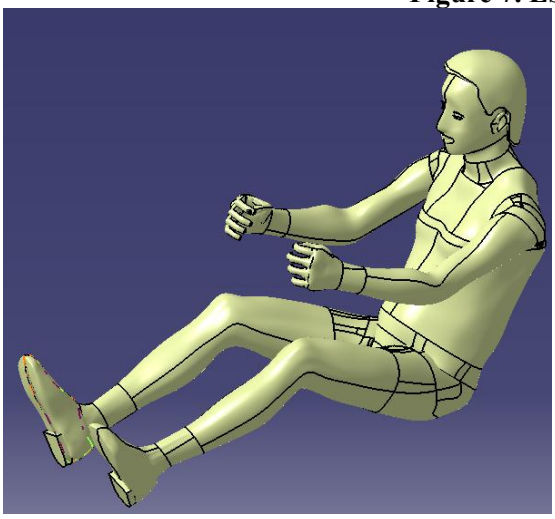


Figure 8. Three-Dimensional Human Body Surface

3.3 Optimization Analysis of Auxiliary Instrument Panel Scheme

In the research and development project of new energy passenger car, we verified the three-dimensional human body and the auxiliary dashboard, and found that there is about 3mm interference between the right knee of the human body and the upper part of the auxiliary dashboard, as shown in **Figure 9**. For this kind of problem, ordinary two-dimensional human body models cannot be intuitively discovered in the process of human posture design. Therefore, using RAMSIS software to generate 3D human body data according to the methods mentioned above for simulation analysis can serve as a good design supplement which also conducting scheme verification to identify problems and optimize ergonomics design schemes. To address this issue, we can modify the shape of the auxiliary dashboard to avoid interference and meet the requirements of ergonomics space.

3.4 Optimization Analysis of Tweeter Scheme

In the research and development project of new energy passenger car, the tweeter is required to arrange vertically and have a deviation of +5° to -0 ° from horizontal 0° to the position of the human ear hole for standard sitting collision testing, as shown in **Figure 10** (a). Similarly, the method mentioned earlier will be used to generate three-dimensional human body data which will be imported into the design environment of the tweeter to simulate the relative position relationship between the human body and the tweeter in the real environment, in order to verify whether the relative position relationship meets the layout requirements. We found through verification that the angle between the A-pillar tweeter and the ear hole position is 7 ° , which is greater than the requirement of 5 ° , as shown in Figure 10 (b). Therefore, this solution does not meet the layout requirements and will cause a decrease in the tweeter's sound effect experience. It is necessary to adjust the tweeter's direction to optimize the tweeter's sound effect.

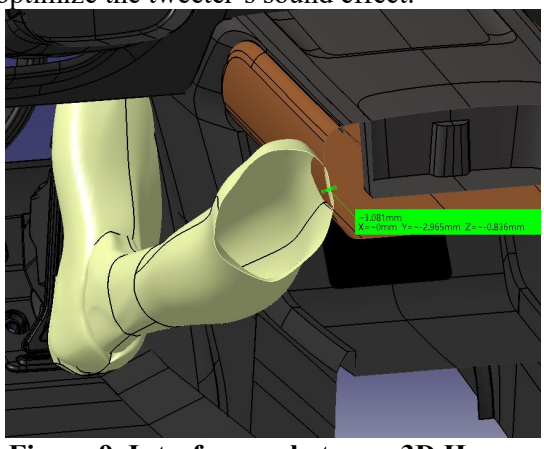
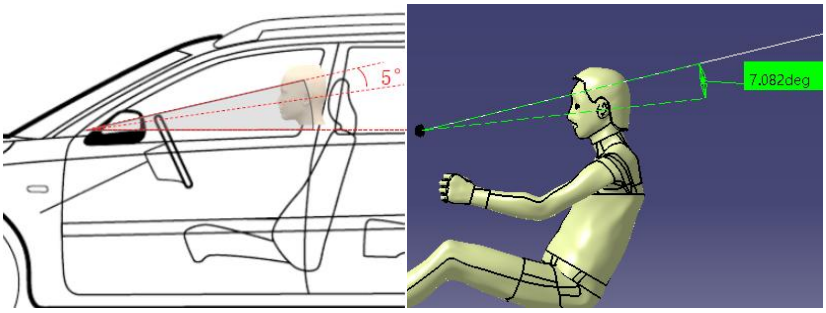


Figure 9. Interference between 3D Human Legs and Auxiliary Dashboard



(a)Technical Requirement **(b)Scheme Check**

Figure 10. Verification and Analysis of Tweeter Scheme

3.5 Optimization Analysis of seat Belt Scheme

As an important device to ensure the safety of cars and passengers, seat belts can effectively reduce the damage to passengers and vehicles in the event of a collision [9]. One of the functions of RAMSIS software is to conduct ergonomics comfort analysis of car seat belts [10]. In the research and development project of new energy passenger car, after completing the human body posture definition, click on the "Modules" command in the toolbar, and then continue to click on commands such as "Belt analysis", "Manikin", "Definition", "Define" to set three parameters for seat belt fixing points. Based on the above settings, RAMSIS can generate seat belt simulation results, as shown in **Figure 11**. The simulation results show that 95% of the human seat belts in this scheme have a distance of 75.4mm or more(≥10mm) from the neck edge, which meets the comfort requirements. However, the distance between the seat belt and the shoulder edge is negative (-6mm), indicating that the seat belt may experience shoulder slippage, which does not meet the requirements of comfort and safety. Therefore, it is necessary to optimize the design of the seat belt scheme.

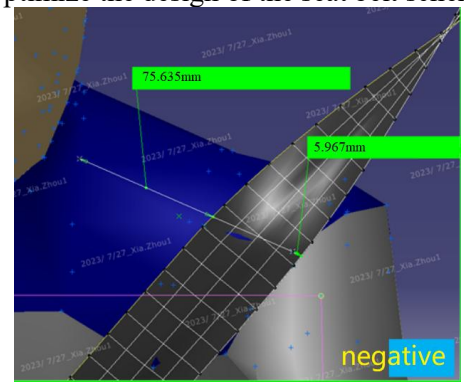


Figure 11. Simulation Results of Seat Belt Comfort Evaluation for 95% of the Human Body at the Designed R-Point Position

4. Conclusion

In the research and development project of new energy passenger car, RAMSIS software can define the size of the human body according to different situations and requirements, and then set a reasonable posture of the human body and can create a three-dimensional human body model. When the 3D human body model is used in combination with the 2D human body model in the scheme design, it can achieve more complete and comprehensive scheme verification and analysis, thereby improving the quality of the design scheme. According to the optimization analysis process of the design schemes such as the auxiliary instrument panel, high pitched speaker and seat belt mentioned earlier, it can be concluded that we used RAMSIS software to carry out ergonomics design and optimization of the vehicle model. We solved many ergonomics problems which reflects the advantages of RAMSIS software in convenient, accurate and intuitive of ergonomics design, and it will play an increasingly important role in many projects in practical work.

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