Computer Modeling: The Future of the Car Industry

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Abstract. In this digital world, the computer is getting more and more useful., Over the course of several decades, computer have been really powerful beyond our wildest dreams. Especially in the car industry, computers have been widely used, because using computer to model the cars can have lots of advantages. With the help of the computers, people can improve their working efficiency and personal safety. What's more, cars can also be safer, cheaper and higher performance by using computer. At first, the software like CAD was only used to directly engage in drawing graphics and making structure design. However, the software which was applied today nearly engage in every part of the cars. Computer modeling have already be a tendency. In this paper I will summary the advantages of the computer modeling and show how to use computer to model the casrs. In the end, I will also write the future development of the computer modeling.

Keywords: Computer model, dynamic, cars.

1. Introduction

In today"s society, the number of car is increasing really fast. According to a research of CAAM, in 2021, automobile production and sales of 26.082 million units and 26.275 million units, an increase of 3.4% and 3.8% year-on-year [1]. Before cars are sent into the market, they need to be detected to see if they are qualified. What's more, when the car company build cars, they also need to model to check the performance of the cars. However if they use the real cars to detect, it will cost a lot of money. In addition, detecting the real cars also need large site, expensive facilities, big team and so on. Whereas using computers to model cars is a really cheap, convenience and effective. Thanks to the development of electronic information technology, people can just use some apps to model the dynamic of a car. Using computer to detect is cheap and convenience. A researcher in the vlog also find out that the use of computer modeling to determine fuel consumption has been on the rise in recent years. In the past there may have been various models, a combustion system model, a transmission model, a battery model and a model of related components, and then, perhaps, another model for analyzing climate control settings and aerodynamics. Each model worked independently, for example, the engine model was designed to maximize combustion efficiency. The development of computing power has improved accuracy. Although individual models have not yet been used to predict the overall effect, the models have been correlated and are now able to be used to rate fuel consumption. Not only in the part of fuel consumption, there are still many parts of the car can be modeled by computer [2].

2. Body

2.1. Development

With the increasing complexity of mechanical systems, the dynamics modeling of systems. The complexity of mechanical systems is increasing, and the dynamics modeling of systems is becoming more and more demanding. The traditional modeling method requires a lot of labor and material resources to complete the modeling of a complex system, and the maintainability of the model is poor. This has seriously hindered the development of simulation technology. With the development of computing technology, simulation modeling theories have been increasing and gradually improved, such as CYCLONE method, SIREN method, RESQUE method. Zeigler's multi-level modularity modeling idea proposed by Zeigler has achieved great success in practical application. The modeling ideas such as CYCLONE method, SIREN method, RESQUE method and Zeigler's multi-level modularity have been applied with great success [3].

At first, people mostly use Computer Aided Design (CAD) which was invented in 1950s. The understanding of CAD can be divided into three levels, each giving a different interpretation of "D": development, drawing, development. When making the engineering and product design, computers can help designers with calculations, information storage, and drafting. In design, computers are mainly used to solve a lot of calculations, analysis, and comparison of diverse solutions to select the best solution; various design information, whether digital, textual, or graphical, which can be stored in computer memory or external storage and can be retrieved rapidly; designers usually start their designs with sketches, and the hard work of converting sketches into working drawings can be left to computers; computers can be used to Process Graphic Data The work of editing, enlarging, reducing, panning, and rotating graphics can be done with a computer. Popular commercial CAD software used in the automotive industry include UG, CATIA, and ProE. [3]

2.2. Main CAD software

UG: Work on UG began in 1969 and is based on the implementation of the C programming language. It is an interactive CAD/CAM system that is strong and can easily realize the construction of diverse complex solids and shapes. In its early days, it was mainly based on workstations, but with the development of computer hardware and the rapid growth of individual users, the PC application achieved rapid growth and became the main application of 3D design in the molding industry.

CATIA: The modular CATIA family of products provides product styling and form design, mechanical design, equipment and systems engineering, managing digital prototypes, machining, analysis and simulation. CATIA products are based on the open and scalable V5 architecture. By enabling companies to reuse product design knowledge and shorten the development cycle, CATIA solutions accelerate the response of companies to the needs of the marketplace. Its digital prototyping process has been widely adopted in the market since 1999, making it the most commonly used product development system in the world.

ProE: ProE was the first to introduce the concept of parametric design and uses a single database to address the relevance of features. In addition, it adopts a modular approach so that users can choose according to their needs without having to install all the modules. Pro/E's feature-based approach enables the integration of the entire design-to-production process for parallel engineering design. It can be applied not only to workstations, but also to stand-alone machines. Pro/E uses a modular approach that allows for separate sketching, part creation, assembly design, sheet metal design, and machining processes, ensuring that users can choose to use them as they see fit.

With the rapid development of electronic information industry, CAM have been used more and more. CAM (Computer Aided Manufacturing) mainly means: the application of computer-aided completion of the whole process from production preparation to product manufacturing, that is, by directly or indirectly linking the computer with the manufacturing process and production equipment, the use of computer systems to plan the manufacturing process, the management and control of production equipment and operation of the plant, the processing of data required for the manufacturing process of the product, the control and processing of material flow (blanks and parts, etc.), the testing and inspection of products, etc.. Finally, people invented computer aided engineering (CAE), CAE refers to computer-aided engineering in engineering design refering to the use of computer-aided solution to analyze the structural mechanical characteristics of complex engineering and products, as well as the optimization of structural characteristics, etc., to organically organize all aspects of engineering (production), the key to which is the integration of relevant information, so that it is generated and used in engineering (product) The whole life cycle. And CAE software can be used for static structural analysis, dynamic analysis; study of linear and nonlinear problems; analysis of structures (solid), fluids, electromagnetic, etc.

2.3. Main CAE/CAM software

(1) MSC.ADAMS: Automatic Dynamic Analysis of Mechanical Systems (ADAMS) is a full-featured system dynamics analysis software, which is from the American MSC. It can be applied to easily create parametric solid models and use the principle of system dynamics with multiple rigid bodies for simulation calculations and performance analysis of electromechanical product

ADAMS software consists of 5 types of modules: basic modules, extension modules, interface modules, specialized field modules and toolboxes.

ADAMS/Car has been commonly used in the automotive field. ADAMS/Car absorbs the design and development experience of Audi, BMW, Renault and Volvo, etc. It can quickly build high-precision vehicle subsystem models and complete vehicle models, and can visually reproduce the vehicle kinematics and dynamics simulation under various operating conditions through high-speed animation, and Output performance parameters characterizing stability, braking, ride comfort and safety, etc.

(2) ANSYS: ANSYS is a large general finite element analysis software integrating structural, fluid, electric field and sound field analysis, developed by ANSYS, Inc. The basic functions of ANSYS include: structural static analysis, structural dynamics analysis, structural nonlinear analysis, flexible body motion analysis, thermal analysis, electromagnetic field analysis, computational fluid analysis, sound field analysis, etc. The results obtained from the ANSYS software indicates that the optimal value could be achieved by changing the profile of the curves. The most important variables affecting the performance are vane numbers, inner and outer radius and also the thickness of the rotors. In automotive design with ANSYS, the pre-processing stage requires the operation of "defining load information".

(3) MSC.NASTRAN: MSC.NASTRAN is a large structural finite element analysis software launched by the American MSC. NASTRAN has an open structure and a fully modular organization, so that it not just has a strong analysis capability and also ensures good flexibility, users can select and combine modules depending on their engineering problems and system needs to obtain the best application system. In addition, MSC.NASTRAN provides users with the development tool DMAP language.

The main functions of MSC.NASTRAN include: static analysis, buckling analysis, dynamics analysis, nonlinear analysis, heat conduction analysis, etc. It can also perform such functions as aerodynamic elasticity and heat conduction analysis. It can also perform such functions as aerodynamic elasticity and flutter analysis, fluid-structure coupling analysis, multi-body superunit analysis, advanced symmetry analysis, design sensitivity analysis and optimal design, etc.

(4) LMS.SYSNOISE

SYSNOISE is a large acoustic analysis software developed by LMS Belgium, which is used to calculate the sound pressure, acoustic radiation power, sound intensity at any point in the sound field, the radiation power and energy density of the structure to the sound field, the modalities of the fluid, and can calculate the acoustic vibration coupling problem. It can also be combined with other finite element software (e.g. NASTRAN) for noise reduction optimization design.

LMS.SYSNISE itself does not have pre-processing functions, but it can have interface program connection with many mainstream finite element analysis software, from which the model data of finite elements can be read, as well as modal, surface vibration velocity and other calculation results, thus improving the modeling speed.

(5) MATLAB/Simulink

Simulink is a general simulation package for dynamic systems developed by Mathworks. simulink provides users with a graphical interface for modeling with block diagrams, which allows complex systems to be modeled with a single click and drag-and-drop mouse operation. It provides a faster, more direct and clear way, and the user can immediately see the simulation results of the system.

In the development and design of automotive electronics, it needs to link the controller to a model of the control object in order to perform a simulation analysis to predict or estimate the control effect of the whole vehicle system. Given that MATLAB/Simulink has distinct advantages in building a controller model. [4]

2.4. Advantages on efficiency

Thankds to the powerful computer, people can use computer to detect many parts of the cars For example, Mercedes-Benz uses computer modeling to optimize the aerodynamic performance of the CLA Norbert Fecker, head of the Mercedes-Benz CLA body aerodynamic improvement project, said, "To enhance the aerodynamic performance of a car and reduce its wind resistance coefficient requires improvements in every detail, even if each detail part is improved by only one thousandth, then the combined force is also very considerable." Reducing the vehicle wind resistance coefficient by a single solution is far from enough, it requires constant and continuous improvement on each component, such as the rear trunk lid to adjust a little higher, the engine cover stripes change some, and so on. Engineers tested the vehicle using a wind tunnel, individually testing any component that could improve aerodynamics, from the wheel arches to the rear spoiler. Although the Mercedes-Benz CLA is the latest version of the Mercedes-Benz A-Class hatchback and has the same platform and powertrain as the Mercedes-Benz A-Class, none of the body parts are the same as the rest of the series except for the panoramic sunroof and the tilt angle between the hood and A-pillar, which meant that the engineers needed to analyze and test each part again. The wind tunnel uses a 9-meter diameter fan with a maximum airflow speed of 265 km/h to simulate the car driving in realistic road conditions.

During the design of car seats, CAD/CAM computer graphics are used to create models of fabric products. Computer-aided industrial design (CAID) is the name given to computer-aided industrial design (CAID) among automotive and parts manufacturers, and some examples of CAID are in practice used in the design of respectable car exteriors. However, there is little practical use for models of fabric products because of the difficulty of creating images with reflective properties of the fabric. We developed a method which can create computer graphics of fabric-covered car seats using a bidirectional reflectance distribution function (BRDF) and computer colour matching (CCM) [3]. The main parts of the energy loss of each component within the locomotive exhaust system can be found with three-dimensional CFD data calculation techniques. One can improve the power and economy of the engine by improving the energy loss areas. [5]

Computers can also help people’s trip. For example, a kind of online car is a product of the "Interonline+ " era. As a new intelligent way of urban transportation, it breaks the old model of taxi service. [6]

2.5. Advantages on the safety

About the safety, let’s me introduce EuroNCAP Pedestrian Protection Protocol Analysis. Since pedestrian protection has a lot to do with vehicle, the shape and layout of the vehicle, it would be too late to make improvements in pedestrian protection until the vehicle is built. It is too late to improve pedestrian protection until the vehicle is built. Therefore, CAE simulations can be used to guide the vehicle styling and layout to shorten the development time and reduce the development cost. EuroNCAP pedestrian protection test method is divided into 4 parts, Leg form and Bumper; Upper Legform and Bonnet Leading Edge and Bonnet LeadingEdge (BLE); Child Head and Vehicle Structures Headform and Structures; Adult Headform and Structures The Adult Headform collides with structures. In each subsystem, the number of collisions is specified. The lower leg collides with the bumper 3 times, and the upper leg collides with the bumper 3 times. 3 times, the upper leg collided with the front edge of the hood 3 times, and the child and adult collided with the structure of the vehicle 3 times. The maximum number of crashes for each test is 2 and the minimum is 0. The maximum score for each test was 2, the minimum score was 0, and the maximum total score was 36. Score for each test. The scores were scaled linearly from 0 to 2. Finally, the scores of each test are summed to obtain the pedestrian protection star rating,

28 to 36 is 4 stars, 19 to 27 is 3 stars, 10 to 18 is 2 stars, and 1 to 9 is 1 star. All those things are done by the computers.

We can use computer to model some damage of the vehilcle. A group of researchers use computer to model freight cars and directly predict the damage of the car. As a result, people can prevent some traffic accidence by timely maintence. [7] What’s more, we can use computers to detect the car tire pressure. People usually use Tire Info System (TIS) continuously measure the pressure inside that tire, generating alert to the driver when a pressure loss occurs.[8]

Some scientists also uses Fadhloun-Rakha (FR) to do 5 things: (1) explicitly models driver throttle and brake pedal inputs in a single continuous equation; (2) explicitly captures driver perception and control inaccuracies and errors; (3) models vehicle dynamics using a point mass model; (4) allows for shorter distances than steady-state following when following faster leading vehicles; and (5) guarantees collision-free driving.

e Info System)

2.6. Advantages of applying computer simulation technology in teaching

Computer simulation is used to set up a simulation model on the computer to imitate the response of the actual system and its process of change with time, and to obtain the simulation output parameters and basic characteristics of the simulated system by the observation and statistics of the simulation test process, so as to estimate and infer the real parameters and real performance of the actual system, so that the system performance and long-term dynamic characteristics can be fully realized by computer in a very short time. Realization. In view of the reality that some of the theoretical derivations in the teaching of "Automotive Theory" are complicated and some experiments are difficult to be realized in the usual experimental teaching, here, the computer simulation technology is incorporated into the teaching, which has the following advantages.

(1) Low cost. Experimental equipment is usually more expensive, as little as tens of thousands, more than hundreds of thousands of millions. The use of computers, and loaded with simulation software, can achieve multiple courses of multiple experiments simulation, can make all students get on the opportunity at the same time, can partially reduce the expenditure on experiments.

(2) flexibility, intuition is stronger. Through the simulation software, several different simulation models can be established, and the simulation results can be compared by adjusting the input of the model or changing the parameter values of the simulation model, so as to analyze the main factors affecting the system characteristics. The simulation results can be displayed in the form of graphics or animation, which is convenient to visualize the complex theory and enhance the teaching effect.

(3) High security. Some of the experiments in the teaching of "Theory of Automobile", such as braking experiment and maneuvering stability experiment, have certain danger in the process of experiment. Students build simulation models under the simulation software, carry out simulation, and compare and analyze the results, without the danger of field experiments. [9]

Automobile chassis dynamometer is a loading device for load testing and adjustment of the car. In order to effectively realize the simulation of automobile road driving conditions, it is necessary to show the resistance of the automobile running in the road through the dynamometer, the simulation mainly includes flywheel simulation and point simulation, especially the eddy current chassis dynamometer, as long as the excitation current size is changed, it can realize the change of the active roller resistance torque, which provides a variety of possibilities for the computer simulation of automobile driving conditions resistance and convenient [10]. Computers can transmit the results of monitoring and diagnosis to the server in the workshop. [11]

2.7. Advantages on reducing the cost

A group of researchers used a fuel consumption model, SEFUM (Semi Empirical Fuel Use Modeling) and compared with three models from the literature on a 600 km experimental database. With the help of the SEFUM, people can accurately detect the cumulated and instantaneous fuel consumption. As a result, it will be much easier for people to reduce the fuel cost of a car. [12]

2.8. Today's applications

In today's society, people often use computer to model the behavior of the cars. Tongji University use many data and research samples to find out that IDM can have a good influence on dectecting the cars behavior when they are driving on the Freeway. As a result, it will improve the Human–computer interaction, thus contributing positively totraffic safety. [13]

3. Conclusion

As we could see, the computer model has made great contributions to the car industry. It can reduce the cost of the car companies, improve cars' safety and improve cars' performance. What's more, technology of computer modeling on cars is getting more and more mature. There are many kinds of software which we can use and their applicants are really wide.

Future cars development direction are mainly about autonomous driving, new energy, Internet of vehicles and so on. In these fields, computers are vital important because the implementation of these things is based on computers. Thus, computer modelling is becoming increasingly important. The majority of users are young white-collar workers in urban areas with established families; they are engaged in front-end technology, enjoy life and have to take care of their families; having grown up in an era of rapid scientific and technological progress, users now appreciate the intelligence and convenience of a car's HMI. [14]

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