Application of Integrated CAE Simulation Platform in Future Tank Design

Fengjun Qi, Xuefei Wang*

Army Academy of Armored Forces, Changchun, China

[a]2267044484@qq.com; [b]faye_snow_xue@126.com

* The corresponding author

Keywords: Integrated simulation technology; Tank design

Abstract: The integration of CAD, CAE and CAM technology to realize the functional design of tank components and the whole system, the evaluation of design indexes and sample processing is of great significance to reduce the development cost of new type tanks and shorten the development cycle of new type tanks. It has changed the traditional mode of tank research and development and the integrated design technology of foreign tanks. Application has been very mature, almost penetrated into all aspects of tank development. With the rapid development of independent research and development capability of domestic tanks, the integration technology in tank design is one of the core technologies in vehicle development. To master and make good use of the integration technology is the key to shorten and catch up with the advanced level of foreign countries. Based on the important role played by the integration technology in the design of foreign tanks, this paper expounds the integration technology. The problems existing in the application of integrated technology are described, and the corresponding countermeasures and suggestions are put forward to promote the leapfrog development of tank design in the future.

1. Introduction

Tank armored vehicle is a complex weapon system with firepower, maneuverability, protection and information functions, and integrates mechanical, electrical, hydraulic and optical technologies. Its tactical and technical performance requirements are as many as dozens. Its design is based on contemporary scientific and technological research, and creatively applies in many aspects under the condition of meeting the technical performance requirements. Technology is the process of dealing with contradictions and determining technical documents and engineering drawings. Tank design should not only coordinate the structure among various performances, general layout and components, but also solve the contradiction between use and production, that is, between the advanced performance of products and the possibility of production, so as to achieve a high level of comprehensive performance of products and produce them economically. Only in this way can the developed tanks be equipped or used in battlefield effectively and accomplish their tasks well in battle.

The technical comprehensiveness and structural complexity of tank determine that its development is a process of research and innovation. It takes 3-5 years to reach the product design and production finalization. It takes longer to reach the modern high-tech level, about 10 years. The development cycle will be shorter if the existing models are improved or the variant cars are designed with reference models. Usually hundreds of technicians participate in the development. Therefore, reducing the cost of new tank development and shortening the product development cycle are urgent problems to be solved in tank design. The integrated CAE simulation technology takes computer as the hardware carrier and uses corresponding software to realize the modeling of tank components and systems, numerical technology and sample processing technology. Based on this platform, the strength, stiffness, buckling stability, dynamic response, heat conduction and three-dimensional multi-dimension of complex engineering and product structures can be solved. An approximate numerical method for the analysis and calculation of mechanical properties such as body contact, elastoplasticity and the optimization design of structural properties. On the one hand,

  DOI: 10.25236/iciss.2019.051

the application of integrated simulation technology has made many complex problems that could not be analyzed under the restriction of conditions in the past, which have been satisfactorily solved by integrated simulation technology. On the other hand, integrated simulation technology has simplified a large number of complex engineering analysis problems, made the complex process hierarchical and saved a lot of time. It avoids low-level repetitive work and makes engineering analysis faster and more accurate.

2. Overview of Integrated Simulation Technology

Integrative simulation technology integrates CAD, CAE and CAM technologies to realize product digital modeling, numerical technology and sample processing. In this process, there are two key technologies: one is the collaboration between CAD digital model and CAE simulation calculation system, that is, to ensure that the digital model of CAD environment will not lose data in the CAE calculation environment; It is the checking and evaluation of CAE calculation results and suggestions for improvement. As the core of simulation technology, CAE technology is the finite element analysis technology based on modern computational mechanics. The basic idea of CAE technology is to decompose the solution region of a complex continuum into a finite and simple sub-region, that is, to simplify a continuum into an equivalent combination of finite element groups; by discretizing the continuum, the field variables (stress, displacement, pressure and temperature) of the continuum are solved. It is simplified to solve the field variables on finite element nodes. At this time, the basic equation to be solved will be an algebraic equation system, rather than the original differential equation system describing the real continuum field variables. The approximate numerical solution will be obtained. The approximation degree of the solution depends on the type and quantity of the element used and the displacement interpolation function of the element.

CAE has been applied in engineering since the early 1960s. It has gone through more than 50 years of development. Its theory and algorithm have gone through a process from vigorous development to maturity. Now CAE has become an indispensable numerometer in engineering and product structure analysis (such as aviation, aerospace, machinery, civil structure, etc.). The calculating tool is also an important means to analyze various problems of continuum mechanics. With the popularization and continuous improvement of computer technology, the functions and calculation accuracy of CAE system have been greatly improved. Various CAE software based on product digital modeling emerged as the times require, and has become an important tool for structural analysis and optimization. CAE software can be used to analyze the reliability of performance and safety of engineering and products, simulate their future working state and operation behavior, find design defects as early as possible, realize optimization design, improve design quality, reduce research and development cost and shorten research and development cycle. At present, common commercial CAE software includes ANSYS, MSC. NASTRAN, ABAQUS, IDEAS, MARC and so on.

3. The Role of Integrated Simulation Technology in Tank Design

3.1. Tank Design Process.

3.1.1. Planning and Demonstration Stage

Starting with the concept of the need for a certain kind of vehicle, or even the formation of a new vehicle, a thorough investigation, comparison and Discussion on military needs, strategic and tactical viewpoints, geographical and climatic conditions, scientific and technological levels, production and manufacturing capabilities, national defense funding, the quality of troops and logistical support are carried out, and a clear list is made. Type planning and equipment development plan of armored vehicles loaded into tanks. According to the purpose and method of use, combined with the operational characteristics of our army and the regional characteristics of our country, the simulation test of combat effectiveness and confrontation of equipment is carried out, the corresponding tactical and technical requirements are put forward, the specific performance

indicators are defined, and the procedural evaluation and approval are used as the basis for development.

3.1.2. Research Stage

Before the development task is given, according to the forecast of the demand and the direction of the development of science and technology, the pre-research and test of new technology and components are carried out according to the planned subject, and the technical preparation is made. After accepting the task, based on the pre-research already carried out, the overall scheme and key technologies are studied and tested, and the feasibility of the new technology, new components and overall scheme is verified, which lays a good foundation for the next development work.

3.1.3. Design Phase

According to the tactical and technical requirements of the demonstration, on the basis of the existing technology of tank armored vehicles and pre-research results, the overall design is carried out first, and the overall scheme is determined. After the overall scheme and design evaluation are passed, the component design and part design are started. In the process of completing design calculation and engineering drawings, the general scheme and component structure are supplemented or modified.

3.1.4. Trial Production Stage

Generally, it can be divided into principle prototype stage, initial prototype stage and positive prototype stage. Sometimes different parts and prototypes of more than one scheme are also trial-produced at the same time. For the important parts, the bench test should be carried out first. The bench test shows that the corresponding key technologies have been broken through and the function and performance indexes have met the requirements before the loading test can be carried out. Through trial-manufacture and test, the rationality and economy of design, technology and other aspects can be tested, especially whether the target of tactical and technical requirements can be met, and various problems can be found for modification, sometimes even major modification, until the performance requirements can be met. Only after comprehensive tests, including adaptability tests in hot and cold regions, and qualified, can the design be finalized.

3.1.5. Production Stage

The factory prepares production according to the design stereotyping drawings and technical documents. It mainly produces the eastern line and coordinates the fixed points, including determining the process and process schedule, designing or improving the production line, designing, manufacturing or purchasing new process equipment, researching and mastering new process technology, arranging fixed-point cooperation and material supply, and organizing. Production. Firstly, small batch production is tried out, and troops are equipped for trial use. Only when the production process is stable and the product quality basically meets the requirements, can we approve the product production finalization and enter the formal mass production.

3.2. Integrated Simulation Technology and Tank Design.

Integrative simulation technology is mainly used in the engineering design process of tank design process. It can simulate the performance and working condition of parts and even the whole vehicle before producing samples and prototypes. It avoids the repetitive process of traditional design-trial-manufacture-test-improvement design-trial-manufacture, and reduces the manpower, material and financial resources. Consumption reduces development costs. Most of the problems of prototype products can be solved by simulation in the design stage, which improves the design quality and efficiency, and greatly reduces the development time and costs.

Integrated simulation technology has changed the traditional design method which relies on experience for qualitative analysis and lacks quantitative data, which makes it possible to reduce weight and optimize performance of products. At the same time, integrated simulation technology can try and compare more design schemes in a short time, so it is possible to obtain the best design.

Design to improve the quality of development. The application of integrated simulation technology also enables some empirical knowledge in the past design to appear in a quantifiable form. At the same time, the flexible, convenient and fast characteristics of integrated simulation technology enable design engineers to provide a large number of simulation test data and technical parameters, increase experience accumulation and enhance design capabilities. CAE technology enables design engineers to pre-evaluate tank structure and performance in product design stage, thus greatly reducing the risk of new product development. At the same time, integrated simulation technology can replace most of the experiments.

4. Problems in the Application of Integrated Simulation Technology and Relevant Solutions

Although integrated simulation technology is gradually being popularized and applied in tank design in China, due to its late start, there is a considerable gap in application depth and breadth compared with foreign advanced level. This gap is not only reflected in the theoretical basis and technology, but also in the support of experiments and the level of software use, but also in the lack of mature analytical standards and procedures.

4.1. Main Problems.

1) Tank design units have not fully understood the function of integrated simulation technology. Although it is widely recognized that integrated simulation technology is very useful in the field of mechanical design, the difficulty of application of integrated simulation technology has not been fully estimated. Many units believe that the software bought back can play an immediate role. . But in fact, it is very difficult to achieve results without experienced integrated simulation technicians. It is not difficult to simply introduce integrated simulation technology. The problem is that it is a long-term process to train and master mature integrated simulation technology, which can be applied to tank research and development and create economic benefits. There are no excellent personnel of tank integrated simulation technology, and the best integrated simulation technology is only furnishing.

2) Tank design lacks perfect integrated simulation technology analysis standard and process. The importance of analytical criteria and processes may not be felt in the initial stage of CAE technology, but with the expansion of the analysis scope of integrated simulation technology (analysis objects gradually develop from single parts to assembly system and vehicle system, analysis types gradually develop from linear elastic analysis to non-linear analysis and multi-physical field coupling). The analysis shows that this importance will become more and more obvious, because for the whole vehicle system, besides the complex structure and link relationship, there are also complex non-linear problems. For example, rubber parts, plastic parts, foam parts and other materials are nonlinear, contact nonlinearity among parts, structural nonlinearity of vehicle and so on. Under such conditions, if each of them makes integrated simulation analysis based on his own technical foundation and experience, it is difficult for different analysts to ensure the consistency of the calculation results, let alone the accumulation and comparison of data.

4.2. Corresponding Countermeasures.

1) Tank design unit should fully understand the role and difficulty of integrated simulation technology, accelerate its own integrated simulation technology team, expand the application field of integrated simulation technology, and improve the application depth of integrated simulation technology.

2) Establish and improve the integrated simulation technology analysis process, standardization and evaluation criteria. There are two ways to establish the analysis standard of integrated simulation technology. One is to establish the evaluation standard of related products through the corresponding verification of test and simulation; the other is to use the experience of relevant industries to assist in establishing their own analysis standard of integrated simulation technology.

3) To correctly understand the relationship between experiment and integrated simulation technology, the emergence of integrated simulation technology has indeed reduced some

experiments. This is also a new tank development model. It is precisely because of the emergence of this model that we stand on a starting line again. However, people mistakenly believe that integrated simulation technology can solve one problem. Yes, this is a very unfamiliar and unscientific point of view.

4) When the application of integrated simulation technology reaches a high level, in order to achieve higher technical and economic benefits, it is necessary to carry out secondary development of the software. The purpose is to make the general software more specialized and reflect the technical standards of enterprises. This is of great significance to the establishment and improvement of new tank development capability.

References

[1] Editorial overview: Process systems engineering: A chemical engineering perspective of the food-energy-water nexus[J]. Dale L Keairns. Current Opinion in Chemical Engineering.

[2] Magnetic fusion energy engineering act of 1980[J]. Journal of Fusion Energy. 1981(2)

[3] Saving fuel and energy resources in foundation engineering[J]. B. S. Fedorov, R. Kh. Valeev. Soil Mechanics and Foundation Engineering. 1982(4)

[4] Time management. Part V: Energy engineering.[J]. McGee-Cooper A. AORN Journal. 1986(6)

[5] Development of lower limb phantoms for engineering and medical applications[J]. Faruk Beytar, Erdem Budak, Aytekin Unlu, Osman Erogul. Journal of Biotechnology.