Journal of Multidisciplinary Engineering Science and Technology (JMEST)
ISSN: 2458-9403
Vol. 11 Issue 9, September - 2024

Comparison between SolidWorks and Creo Parametric in stress solution optimization

Hui-Chin Chang

HungKuo Delin University of Technology, Department of Creative Product Design, Taipei, Taiwan

chang.hcjang@gmail.com

***Abstract*—SolidWorks and Creo Parametric are two major computer-aided design (CAD) software programs that are widely used in engineering design, product development, and manufacturing. While there are many similarities in their functionality, there are some key differences. This article uses two softwares, SolidWorks and Creo Parametric, to calculate the minimum material thickness of a flat plate that is subjected to a concentrated force under the limitations of fixed supports at four corners. The stress generated by the material does not yield, so that when The differences between the two softwares in performing optimization solutions can be compared.**

***Keywords*—CAD,optimization**

I. Introduction

SolidWorks and Creo Parametric are two major computer-aided design (CAD) software programs that are widely used in engineering design, product development, and manufacturing. While there are many similarities in their functionality, there are some key differences. For example; both support parametric modeling, allowing users to create and modify models by defining parameters and constraints, which makes design changes more flexible and efficient. Both have powerful sketching tools for defining 2D geometry before modeling, and these sketches are often the basis for constructing 3D models. Both SolidWorks and Creo Parametric support assembly design, allowing users to assemble multiple parts together to simulate how actual products work. Both can automatically generate drawings that can be used directly for manufacturing, including callouts, dimensions, and tolerances. Both provide finite element analysis (FEA), fluid dynamics (CFD) and other simulation tools to help engineers analyze product performance during the design stage. However, there are still some differences between the two in terms of interface operation or usage situation positioning. For example; SolidWorks has a more intuitive and easy-to-learn user interface, which makes it the first choice for many small and medium-sized enterprises and educational institutions. The Creo Parametric interface is more professional and highly customizable, so it requires a longer learning curve, making it more suitable for large enterprises and professional engineers. SolidWorks is suitable for product design of medium complexity, especially when the number of parts and components is limited. Creo Parametric is more suitable for handling highly complex designs, especially when there are many design parameters. Creo performs well in managing large components and complex surfaces. SolidWorks can extend its functionality through plug-ins and third-party tools, such as CAM, CAE, PDM, etc. Creo Parametric comes with a variety of extension modules, such as Creo Simulate, Creo Direct, Creo Mold Analysis, etc. These modules are closely integrated into the software to provide comprehensive solutions. SolidWorks is mainly aimed at small and medium-sized enterprises, the market price is relatively close to the people, and it has a high penetration rate in the education field. Creo Parametric is aimed at large enterprises and high-end markets, especially in aerospace, automotive, mold and heavy industry and other fields. SolidWorks only supports Windows platforms. Creo Parametric supports Windows and Unix/Linux platforms, providing more flexibility for enterprises that require multi-platform support.

Therefore, this article uses two softwares, SolidWorks and Creo Parametric, to calculate the minimum material thickness of a flat plate that is subjected to a concentrated force under the limitations of fixed supports at four corners. The stress generated by the material does not yield, so that when The differences between the two softwares in performing optimization solutions can be compared.

II. SolidWorks optimization process theory and method

When optimizing designs in SolidWorks, the commonly used theories and methods mainly include the following:

(1) Finite Element Analysis (FEA): Finite element analysis is a numerical method used to solve stress, strain and displacement in complex engineering problems. It breaks down a structure into smaller, simpler elements and predicts the performance of the entire structure by calculating the behavior of each element. When optimizing a structure, the Simulation module of SolidWorks uses finite element analysis to calculate the stress distribution and deformation after design changes, thereby helping users understand the stress distribution of the entire structure.

(2) Parametric Design: Parametric design is the process of generating a design based on a set of defined parameters and constraints. Design

parameters can be size, shape, material properties, etc. During the optimization process, SolidWorks can automatically adjust these parameters to meet certain design goals, such as minimum weight, maximum strength, or minimum cost. This approach is often used in conjunction with design changes, constraints, and objective functions.

(3) Objective Functions and Constraints: The objective function is a function that needs to be minimized or maximized in an optimization problem. It usually represents the volume, mass, energy, etc. of the design. Constraints are limitations imposed on design parameters, such as dimensions, tolerances, or characteristics such as factors of safety. In SolidWorks, the Optimization module automatically adjusts design variables to find the best solution based on design goals and constraints.

(4) Design Optimization Algorithms: These algorithms include gradient descent method, genetic algorithm, Monte Carlo method, etc., used to search for the optimal solution in the design space. The optimization process in SolidWorks uses these algorithms to explore different combinations of design variables to meet or optimize set objective functions and constraints.

(5) Topology Optimization: Topology optimization is a numerical technique that designs structures with the best performance by optimizing the distribution of materials. This approach is generally very efficient in material use because it retains only the necessary material to carry the design loads. The SolidWorks Simulation module includes topology optimization tools that calculate optimal material distribution based on loading and boundary conditions to produce designs with optimal structural performance.

In the design optimization process, SolidWorks uses a variety of theories and methods such as finite element analysis, parametric design, objective functions and constraints, and topology optimization. These tools work together to help users find the best balance between performance, cost and other design goals.

III. Creo Parametric optimization process theory and method

When optimizing designs in Creo Parametric software, the theories and methods used have some similarities with SolidWorks, but they also have their own unique techniques and capabilities. The following are optimization theory rules commonly used in Creo Parametric:

(1) Finite Element Analysis (FEA): Finite Element Analysis is a numerical method that simulates and analyzes the behavior of the design under different loads, including stress, strain, displacement, etc., by dividing the structure into smaller elements. . FEA tools in Creo Parametric (such as Creo Simulate) can be used to analyze the performance of the model under various conditions as part of the optimization process. These results can be used to adjust the design to ensure it meets performance requirements while minimizing material usage or other resources.

(2) Parametric Design and Design Variations: Parametric design allows users to generate and modify models based on set parameters and constraints. These parameters can be dimensions, material properties, boundary conditions, etc. In Creo Parametric, you can set design variables and automatically adjust these parameters to achieve design goals, such as minimizing weight, maximizing strength, or optimizing manufacturing costs.

(3) Objective Functions and Constraints: The objective function is the design criterion that needs to be minimized or maximized during the optimization process (for example: cost, weight, stiffness, etc.). Constraints are used to limit the design variables to change within a certain range to ensure that the design meets necessary specifications or requirements. Creo Parametric uses these objective functions and constraints to guide the execution direction of the optimization process. Users can define design goals and impose constraints, and let the software automatically adjust parameters to find the best solution.

(4) Sensitivity Analysis and Design Studies: Sensitivity analysis is used to evaluate the impact of design variables on the objective function. This analysis helps to identify which parameters are most critical to the design results. Creo Parametric provides sensitivity analysis tools that allow users to test different parameter combinations during the design process and understand the impact of these changes on design performance, and these results can be used to guide the optimization process.

(5) Design Optimization Algorithms: Creo Parametric includes a variety of optimization algorithms, such as gradient method, genetic algorithm, Monte Carlo method, etc., which are used to explore the design space and find the optimal solution. These algorithms are used to adjust design parameters to meet set objective functions and constraints. For example, genetic algorithms can be used to explore complex design spaces to find the best possible solution.

(6) Multi-Objective Optimization: Multi-objective optimization involves optimizing multiple objective functions simultaneously, and these objectives often conflict with each other, such as reducing weight and increasing strength. Multi-objective optimization seeks to find an optimal compromise solution between these objectives. In Creo Parametric, users can set multiple design goals and explore different design solutions through multi-objective optimization tools to find the best design that balances these goals.

(7) Topology Optimization: Topology optimization is a

numerical technique based on material distribution in the design space. Its purpose is to find the optimal distribution of materials under given load conditions to create the optimal structure. In Creo Parametric, the topology optimization function allows users to remove unnecessary material from the initial design, retaining only the parts that need to bear load. This method is particularly suitable for designs that reduce structural weight and improve strength.

In Creo Parametric, the design optimization process combines multiple theories and methods such as finite element analysis, parametric design, topology optimization, sensitivity analysis, and multi-objective optimization. These tools and technologies work together to help engineers optimize design performance while meeting various design constraints. This makes Creo particularly suitable for handling engineering design problems with complex and high-performance requirements.

IV. Gradient Descent

Gradient Descent is a commonly used numerical optimization algorithm suitable for minimizing or maximizing an objective function. This method is widely used in optimization problems in machine learning, statistics, and engineering design. It is an iterative algorithm that gradually approaches the minimum value of the objective function by updating parameters multiple times. The core idea of this method is to gradually move downward (for a minimization problem) along the gradient direction of the objective function until the local or global minimum of the function is found. Its mathematical model and execution steps are described below;

Suppose there is an objective function f(x), where x is the parameter vector we want to optimize. The goal of the gradient descent method is to find the value of parameter x such that f(x) is minimized. The gradient ∇f is a vector that contains the partial derivative of the objective function for each parameter. The gradient indicates the fastest changing direction of the function in each direction. For minimization problems, we should move in the opposite direction of the gradient in parameter space. The execution steps are;

Step 1 Initialization: Randomly select the initial parameter vector x_0, and set the selection learning rate α, which is a parameter that controls the step size of each update.

Step 2 Calculate the gradient: Calculate the gradient of the objective function at the current xk ; $\nabla f(x_k)$

Step 3 Update parameters: Update the parameter vector according to the gradient, the formula is as follows:

$$x_{k+1} = x_k - \alpha \nabla f(x_k)$$

where x_{k+1} is the next parameter vector and α is the learning rate.

Step 4 Check convergence: If the value of the gradient is small enough, or the change range of the parameters is less than the set threshold, the algorithm is considered to have converged and the iteration can be stopped.

Step 5 Repeat the operation: If convergence is not achieved, repeat steps 2 to 4 until the stop condition is met.

The learning rate α controls the magnitude of parameter update in each iteration. Therefore, if the α value is too large, the algorithm may not converge, because each step is too large and will exceed the optimal solution. However, if the α value is too small, the convergence speed will be too slow, and a large number of iterations may be required to find the optimal solution. At the same time, the gradient descent method may fall into a local minimum due to the shape of the objective function. It may also wander near the saddle point (that is, the point where the gradient is zero but not the minimum), causing convergence difficulties.

Therefore, the gradient descent method is an effective optimization technique suitable for many different mathematical models and applications. By iteratively updating parameters, it is able to gradually find the minimum value of the objective function. However, its performance is affected by the choice of learning rate, initial value, and the shape of the objective function. In practical applications, it is often necessary to combine experience and experiments to adjust these parameters to achieve the best results.

V. Practical implementation results

This article uses two softwares, SolidWorks and Creo Parametric, to calculate the minimum material thickness of a flat plate that is subjected to a concentrated force under the limitations of fixed supports at four corners. The stress generated by the material does not yield, so that when The differences between the two softwares in performing optimization solutions can be compared.

If the size of the aluminum alloy 1060 plate is 120 * 70 * 7 mm, the area with a center diameter of 30mm on the upper plane of the plate will bear a concentrated force of 908 N, and the four 7*7 mm square areas on the lower plane of the plate are assumed to be fixed regional boundaries. Its relevant dimensions and boundary conditions are shown in Figure 1:

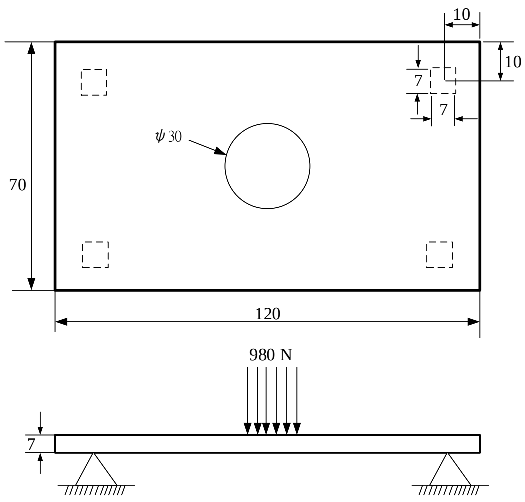

Figure 1 Plate boundary conditions

The physical properties of 1060 aluminum alloy material are;

- Modulus of elasticity : 6.9e+10 N/m^2
- Poisson Ratio : 0.33
- Shear modulus : 2.7e+10 N/m^2
- Mass density : 2700 kg/m^3
- Yield strength : 2.7574e+7 N/m^2
- Thermal expansion coefficient : 2.4e-05 /K
- Thermal conductivity : 200 W/(m.K)
- Specific heat : 900 J/kg.K

Here, SolidWorks and Creo Parametric are used to calculate the minimum thickness of the plate when the plate stress is less than 2.6e+07 N/m2, and to compare the differences between the two softwares in performing optimization solutions.

A. SolidWorks execution results

According to the conditions given above, the distribution of stress and deformation is shown in Figures 2 and 3 through the calculation results of the Simulation module of SolidWorks.

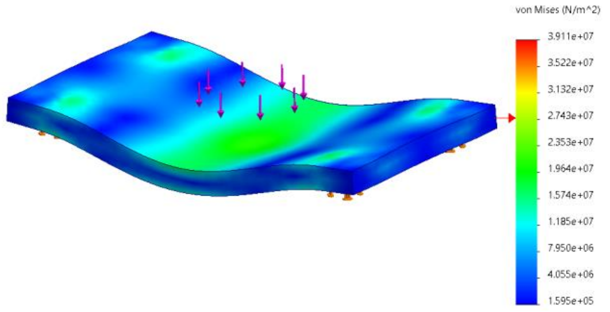

Figure 2 Stress distribution diagram

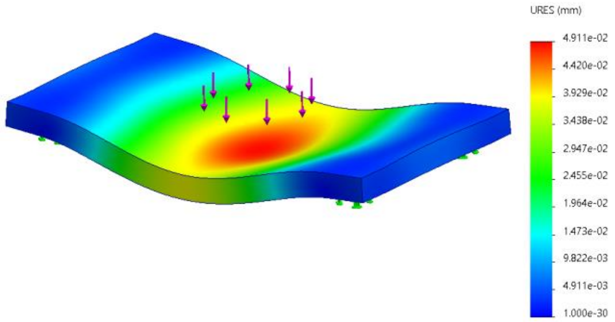

Figure 3 Deformation distribution diagram

It can be seen from Figure 2 that the maximum stress value of this plate is 3.911e+07 N/m2, which is greater than the yield strength of this plate 2.7574e+7 N/m2. It can be seen that if the maximum stress value of the plate is to be between 2.6e+07 ~ 2.61e+07 N/m2, the thickness of the plate needs to be increased. Then proceed to the optimization inference, the search space is 8 ~ 11 mm, and the learning rate α is initially set to 0.2 mm. The initial results cannot converge because the value of the learning rate α is too large, and a suitable solution is found, as shown in Figure 4.

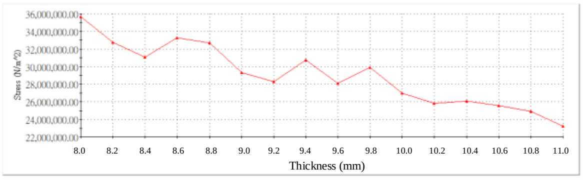

Figure 4 Initial optimization execution results

As can be seen from Figure 4, there is a suitable solution in the range of 10 ~ 10.2, so the search space is reduced to 10 ~ 10.2 mm, and the learning rate α is set to 0.02 mm. After execution, the value of the learning rate α is still too large, so it is still unable to converge and a suitable solution is found, as shown in Figure 5.

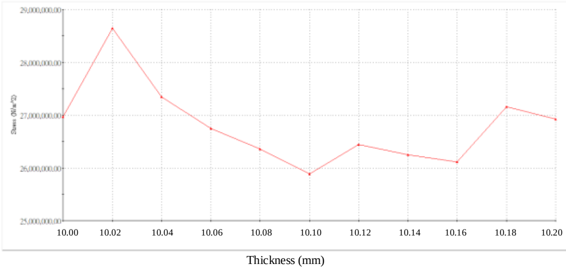

Figure 5 The results of the second optimization execution

It can be seen from Figure 5 that there is a suitable solution in the interval 10.09 ~ 10.10, so the search space is reduced to 10.09 ~ 10.10 mm, and the learning rate α is set to 0.002 mm. The execution results show that when the plate thickness is 10.092 mm, the maximum stress value is 2.601e+07 N/m2, which meets our needs, as shown in Figure 6.

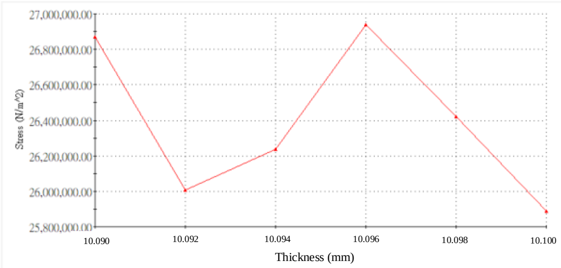

Figure 6 Final optimization execution results

B. Creo Parametric execution results

Similarly, according to the conditions given above, the distribution of stress and deformation is shown in Figures 7 and 8 through the calculation results of Creo Paramatric's Smulation module.

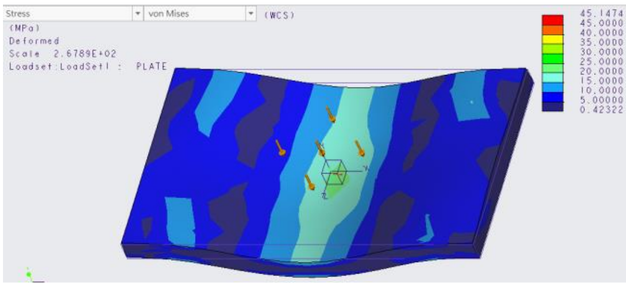

Figure 7 Stress distribution diagram

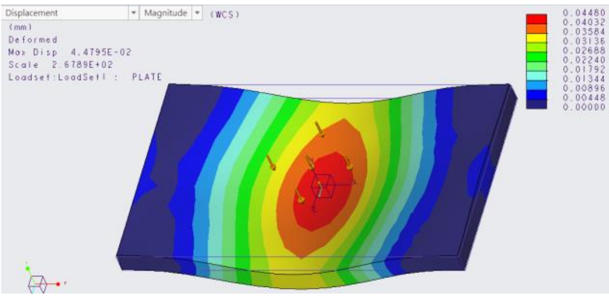

Figure 8 Deformation distribution diagram

It can be seen from Figure 8 that the maximum stress value of this plate is 45.1474 MPa, which is greater than the yield strength of this plate 27.574 MPa. Similarly, if the maximum stress value of the plate is less than 26.01 MPa, the thickness of the plate needs to be increased. Then use Creo Paramatric for optimization inference, and the search space is 8 ~ 11 mm. Using the single-pass Adaptive analysis method, the thickness value is 8.156 mm, and the maximum stress value is 25.7862 Mpa, which meets our needs and converges The process is shown in Figure 9.

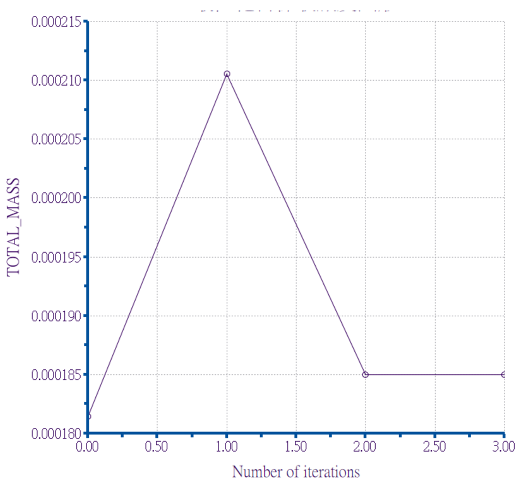

Figure 9 Creo Parametric optimization calculation convergence process

VI. Conclusion

SolidWorks and Creo Parametric are two major computer-aided design (CAD) software programs that are widely used in engineering design, product development, and manufacturing. While there are many similarities in their functionality, there are some key differences. This article uses SolidWorks and Creo Parametric software to execute a 1016 aluminum alloy plate. Under the fixed support limit of 70*70 areas at the four corners, it withstands a concentrated force of 980 N. The maximum stress generated by the material is no greater than Under the premise of 26.01 Mpa, the minimum material thickness is obtained. The optimized calculation results of SolidWorks are as follows: When the thickness of the plate is 10.092 mm, the maximum stress value is 2.601e+07 N/m2. The Creo Parametric is; when its thickness value is 8.156 mm, its maximum stress value is 25.7862 Mpa. The difference between the two is quite large, and the reason may be that the size of the preset mesh divisions and the optimization algorithm are different.

REFERENCES

1. https://zh.wikipedia.org/zh-tw/%E6%A2%AF%E5%BA%A6%E4%B8%8B%E9%99%8D%E6%B3%95
2. Mordecai Avriel (2003). *Nonlinear Programming: Analysis and Methods.* Dover Publishing.
3. Jan A. Snyman (2005). *Practical Mathematical Optimization: An Introduction to Basic Optimization Theory and Classical and New Gradient-Based Algorithms.* Springer Publishing.
4. https://help.solidworks.com/2023/chinese/SolidWorks/Cworks/c_SOLIDWORKS_Simulation_Fundamentals.htm
5. https://support.ptc.com/help/creo/creo_pma/r11.0/chinese_tw/index.html#page/simulate/simulation_live/user_interface_sim_live.html