

Shell Elements Based Parametric Modeling Method in Frame Robust Design and Optimization

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ABSTRACT

Shell Elements based Parametric Frame Modeling is a powerful CAE tool, which can generate robust frame design concept optimized for NVH and durability quickly when combined with Taguchi Design of Experiments. The scalability of this modeling method includes cross members length/location/section/shape, frame rail segments length/section and kick in/out/up/down angle, and access hole location & size.

In the example of the D. O. E. study, more than fifteen parameters were identified and analyzed for frequency and weight. The upper and lower bounds were set for each design parameter based on package and manufacturing constraints. Sixteen Finite Element frame were generated by parametrically updating the base model, which shows this modeling method is comparatively convenient. Sensitivity of these sixteen parameters to the frequency and weight was summarized through statics, so the favorable design alternative can be achieved with the major parameters' combination.

INTRODUCTION

This method enables CAE engineer to verify many ideas with efficiently updating finite element (FE) frame model, therefore find out the most favorable design alternative.

At present parametric beam elements frame model was utilized only in NVH analysis, because durability analysis needs detailed shell elements frame in stress optimization analysis, fatigue analysis, etc. Moreover shell elements parametric frame has an advantage in adding new features, such as joint and cross member section change, or adding subframe.

With applying SDRC-IDEAS, shell elements parametric frame modeling method is presented below step by step. Then an example is presented how to parametrically update the model. Finally with Taguchi Design of Experiments method the sensitivity of the fifteen parameters to the frequency and weight is summarized.

The method can be also used in different component design, such as bracket, etc.

TAGUCHI DESIGN OF EXPERIMENTS METHOD INTRODUCTION [1, 2, 3, 4, 5, 6, 7, 8, 9]

Dr. Genichi Taguchi developed a methodology in which an experiment may be designed to evaluate the effect of several factors and their influence on a product or system. The method utilizes orthogonal arrays wherein the columns of the array represent the factors or variables in the experiment and the rows of the array represent the experiments to be conducted. The factors are typically set at two or three different levels but may have many levels.

The orthogonal feature of the arrays permits the factors to be evaluated somewhat independent of each other. Consequently, far fewer experiments are required to determine the impact of each factor on the system. For example in this frame D.O.E. study, to evaluate all combinations of the fifteen factors at two levels of the vehicle system in this paper would require 32678 experiments. The L12 (211) array estimates the effect with only 16 experiments.

Compared with Taguchi DOE, the classical DOE is more concerned with statistics and model creating and normally does not accommodate more than two levels of each factor

nor lend itself to mixed level designs whereas Taguchi does. Furthermore, Taguchi DOE reduces time by analyzing only the interaction that is believed truly exist, and reduces the cost for reduction of all but necessary interaction.

PARAMETRIC MODELING STEPS [14]

Step 1. Clean the FE Frame

To make it easy to catch geometry feature, the brackets and all 1-D elements are deleted with only two rails and cross members left, as shown in [Figure 1](#).

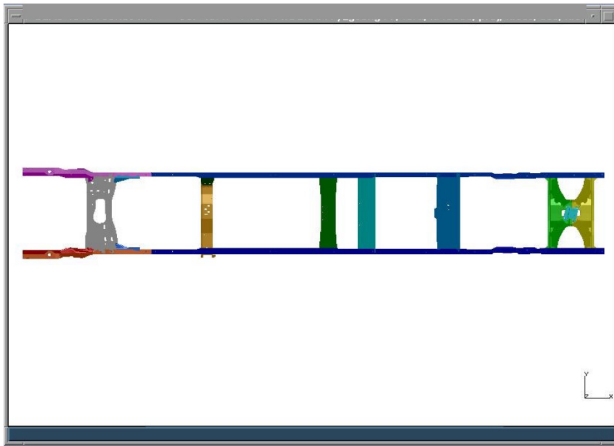


Figure 1. Cleaned FE Frame

Step 2. Load the FE Frame into IDEAS and Model the Parametric CAD Frame

1. Import the frame FE file into IDEAS.
2. Create Parametric CAD Frame Rail
 - a. Taking the Global Coordinate System as reference in translation and rotation, create the first coordinate system at left upper corner point of front rail.

With the same way, create all the rest coordinates for the frame rail in location where geometry changes, and each coordinate system depends on the one before it in translation and rotation.

- b. Create 3D frame rail segment by segment
Selecting Y-Z plane of the first coordinate system, draw the rail section in that location. It is very important for the section to capture the detailed dimension of the FE mesh.

With the same way, create the next two or three sections in next two or three coordinate systems as shown in [Figure 2](#).

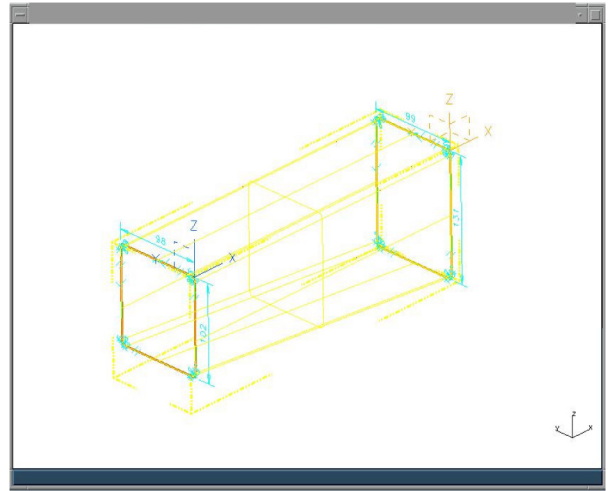


Figure 2. Feature Line and Dimension of the First Rail segment

Selecting these sections, loft to draw the first rail surfaces as shown in [Figure 3](#).

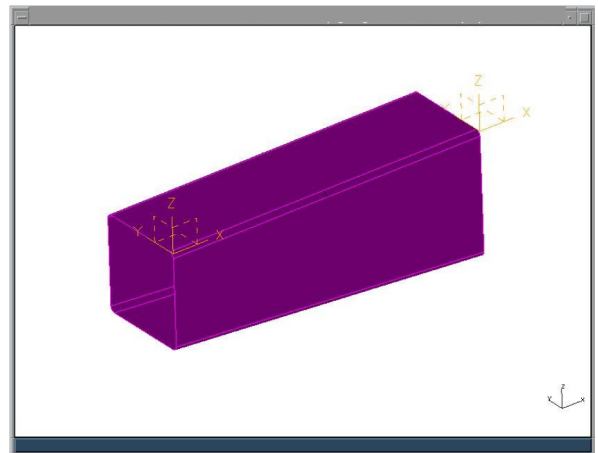


Figure 3. Creating the First Rail segment

With the same way, create other segments and connect them, the whole rail is done, as shown in [Figure 4](#).

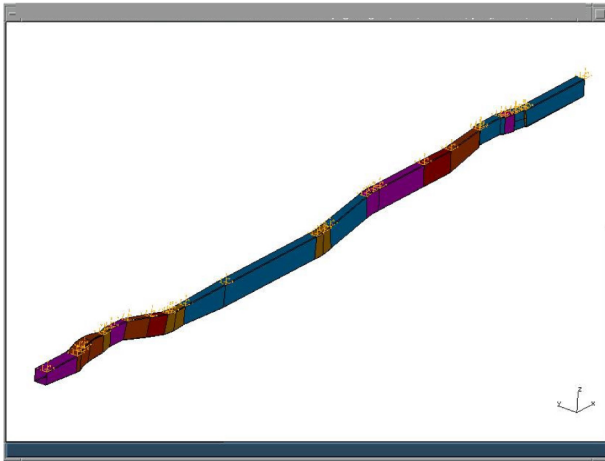


Figure 4. Creating the Whole Rail

3. Create 3D frame cross members segment by segment

a. Taking the first coordinate system as reference, create the coordinate system locating in the middle plane of the frame in #1 cross member.

Using the same way, create the other coordinate systems at the geometry changing location in the #1 cross member.

b. Create the sections at the location of the coordinate system, and select the sections piece by piece to create the half of the first cross member, as shown in Figure 5.

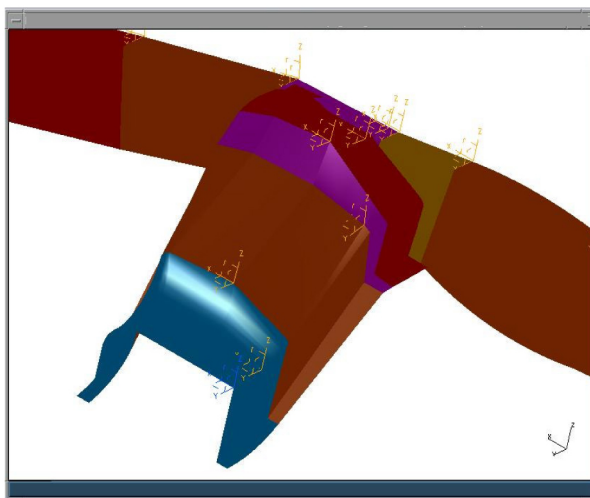


Figure 5. Creating #1 Parametric Cross Member

Create the section and apply it to punch a hole on the #1 cross member, as shown in Figure 6 and 7.

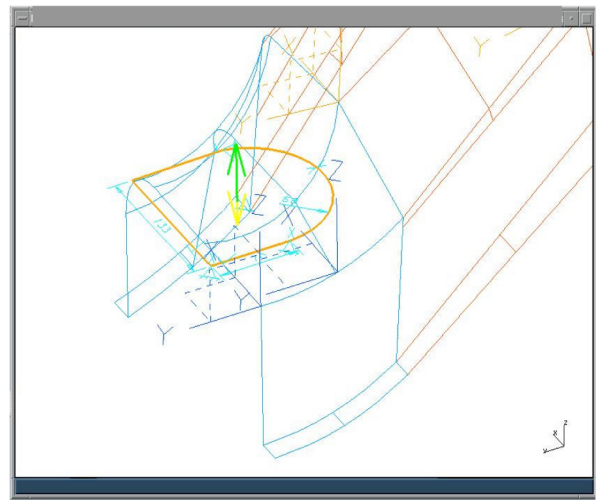


Figure 6. Feature Line and Dimension of the Objective for Cutting the Hole

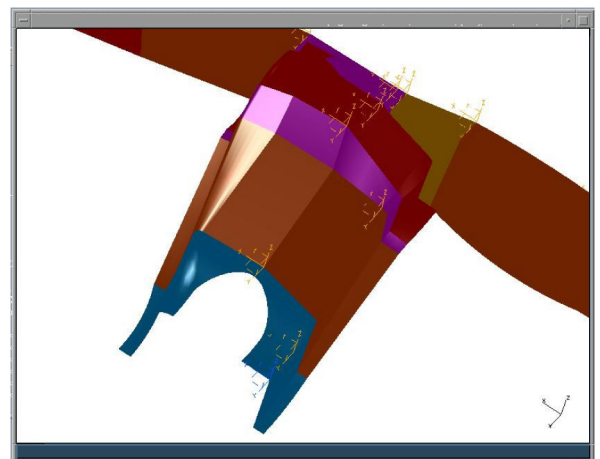


Figure 7. #1 Cross Member after Punching

Apply the same way to create the other cross members and related coordinates systems.

Now the half parametric CAD frame is created, as shown in Figure 8.