Study of Modular Design Capabilities of Part Modules Feature in NX CAD software

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ABSTRACT   Computer-aided design is one of the many tools used by engineers and designers and is used in many ways depending on the profession of the user and the type of software in question. In the last decade, the concept of modularity has caught the attention of engineers, management researchers and corporate strategists in a number of industries. When a product or process is modularized, the elements of its design are split up and assigned to modules according to a formal architecture or plan. NX Part Modules capabilities are designed for work breakup; that is distributed modeling or Modular Design concept.

INTRODUCTION

Current computer-aided design software packages range from 2D vector-based drafting systems to 3D solid and surface modelers. NX is one such parametric solid/ surface feature based package based on Parasolid and is widely used throughout the engineering industry, especially in the automotive and aerospace sectors. In today's world most of the products developed are dependent upon CAD softwares for its design manufacturing and analysis. Thus CAD software occupies a very important position in product life cycle. So if a CAD system wants to survive in the market it needs to be developed and improved continuously without losing the robustness and consistency of the features.

In the last decade, the concept of modularity has caught the attention of engineers, management, researchers, and corporate strategists in a number of industries. When a product or process is modularized, the elements of its design are split up and assigned to modules according to a formal architecture or plan. Hence NX part module capabilities were designed for work breakup; that is distributed modeling or Modular Design concept.

Part Modules is brand new territory for NX. Industries especially from automotive and aerospace world are constantly facing problems in the design of highly complex and large components. Think of design of a door panel of an automobile or air frame design in aerospace industry or design of a die. The part can be any complex part requiring multiple team members working on same single part. While many of today's higher end design tools have functionality allowing multiple team members to work on multiple parts of a same assembly, the same is not the case with a single part.

The Part Module is a suite of commands that introduces Modular Design principles in NX, incorporating functional partitioning, modular interfaces, and ease of change. The smaller portions in which a complex part is divided into, in order to apply a Modular Design approach are called Part Modules. Part modules can be changed with minimal or no effect on the remainder of the part in which it exists. The isolated nature makes them easier to reuse in other parts or as a reference for new parts. The lead designer can update the Part Modules in a part file as and when he wants to view the progress of the features created by other team members. Part module makes a concurrent engineering an easy achievable task. As designers are spread among different disciplines, areas, expertise and country, a single product can't be made simultaneously by such team. Part Modules makes this task possible. This division also makes it easier to display and update the areas at faster rate. The detailed workflow and behavior of Part Modules is discussed in subsequent sections.

In general terms, part module is a collection of feature with a smart behavior. Once lead designer creates a part module, and distributes among designers, he can review changes and progress made by the designers by updating the part module. This simplifies the overall structure of part design adding a great value to today's CAD design workflow. The detailed workflow of Part Modules will be discussed in subsequent sections.

DETAILED CONCEPT

Feature in NX is an object of a class which is smart for its creation, update and deletion. Node is the entry point for the feature in part navigator. A Part Module comprises of three of such step nodes. They are:

- Inputs
- Work
- Outputs

Inputs: Inputs are extractions of (only) previously existing main part geometry, and thus provide a single, well-defined interface between the main part and the front end of the Part Module. Expressions (and other non-geometric data) may also be Inputs.

Work: The Part Module Work is the basic substance of the Part Module. This includes the features, geometry, and non-geometric data that would normally be in the main part, even if a Part Module was not used to collect them.

Outputs: The Part Module Outputs are the user-designated extractions of Part Module Work. Non-geometric data, e.g., expressions, may also be included as Outputs. This output provides a single, well-defined interface between the back end of the Part Module and the rest of the main part. Downstream features of the main part are based on this extracted output of the Part Module, rather than directly on the Part Module geometry itself.
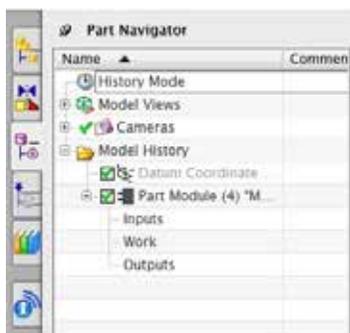

Figure 1: Part Module and its step nodes in part navigator

Creating a Basic Part Module

In a self-contained Part Module all the design work is done solely within the Main part. Firstly create the initial design geometry, in our case, a simple block. Create the Part Module and select the initial geometry and expressions for the Input step-node. The Part Module can be created through Format-> Part Module-> Create. In the name group you can enter suitable name for the module. In the Input References group, with Select Object active, you can select the reference geometry with which you want to work. Refer Figure (2). Once created, you can see Part Module in part navigator. Perform MB3 action on it in order to activate it and star working in it.
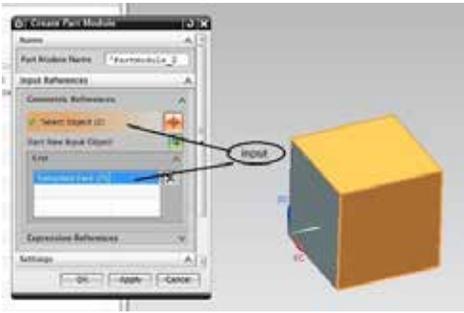
Figure 2: Specifying Part Module Inputs

Using the input geometry, create a new geometry. All the features you create using this input geometry are added to the Work step node. Once all the work is done, you need to specify the Outputs of Part Module. MB3 action on Part Module in part navigator will give you option to specify these outputs. Select all or part of geometry and expressions which you created in work and which you want to refer outside part module. These selections will be added to Outputs step node.

Once all the work is done with a particular Part Module, in the part navigator, right click the part module and choose option Deactivate Part Module. From this point on, you treat the part module as just another feature. Work performed from here onwards will not be part of work node of Part Module. Also if you want to refer any geometry or other non- geometrical data, the data available through outputs can only be used.
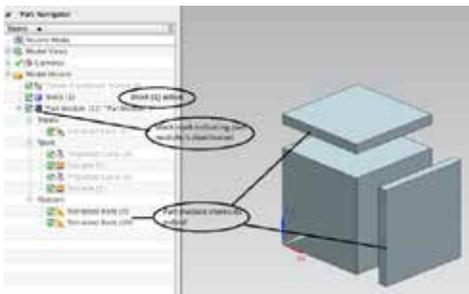

Figure 3: A Deactivated Part Module with its Outputs

**MODULARITY AND CONCURRENT ENGINEERING**
As we discussed earlier, Part Modules were designed for work break-up so that different team members can work on a single complex part depending upon each member's area of expertise. That is along with Modular Design, Concurrent engineering is also the focus of Part Modules. This is where the concept of Linked Part Modules comes into the picture.

The team members could comprise people from different department, or even in some of the cases working in different countries. Now for each of them to work on a single file is not possible. Hence everyone will need one's own set of files which will contain reference geometries/expressions from the main part in order to complete that particular section of main part. This action is facilitated by Linked Part Modules. We will study this concept further with the help of an example.

Here we have considered a part having geometry as shown in the Figure (4). Then we created a part module. Both faces and circles along the curved faces are given as inputs to the part module. Now once inputs have been added, we create a new Linked Part Module by MB3 action. A dialog appears asking you for the path where you want to save this new file. This new file is a regular NX part file. What creation of linked part module does is, it creates WAVE link of inputs of Part Module of main part and places them in the Inputs node of the newly created linked part module. That is it has the same inputs as those inside the corresponding Part Module in main part file. Also it cuts

the data from Work and Outputs node of the part module and pastes them in the corresponding nodes of Linked Part Module. Once linked Part Module has been created, Work node of corresponding Part Module in main part is inaccessible and cannot be modified. WAVE links of outputs are also created.

Fig 4: Inputs of main part to main part module
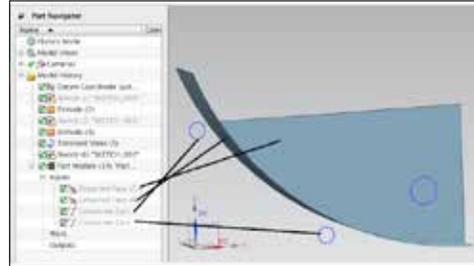
Now, to start working with Linked Part Module, right click on Linked Part Module in part navigator and click make linked work. As soon as you choose this option, the newly created file of Linked Part Module is created. In order to start working with it, one needs to activate it. Once activated, inputs and work are visible whereas the outputs are hidden. Whatever operation you perform using the inputs will be stored inside the work node. Figure 5 shows the work that was performed in Linked part Module. It also shows the outputs which has been provided.

Once the work has been performed, the Linked Part Module is deactivated. In order to go back to the main work, right in part navigator, right click on linked part module and select make main work. Once selected, you will get back to main part. Here, in order to see the progress made in linked part module, you can update the outputs of main part module. The work in linked part module can again be modified. Once it is made sure that no work is going to be modified, you can merge the linked part module into main part module. The merge operation creates copies of the 'Work' objects from linked part module under work step node of part module in main part.

Figure 5: Work and Outputs node of Linked Part Module
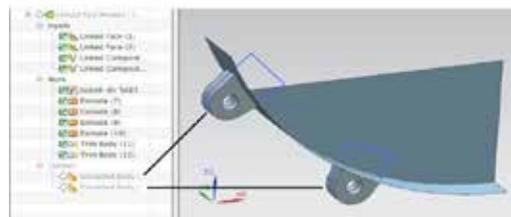
Through above example, we see how a part can be broken into small modules and can be completed by different users on different machines. As we know that a Part Module can be treated as just another feature having set of other features. We see in Figure 5 that it took Extrude (7, 8, 9, 10) and Trim

Fig 6: Less cluster in part navigator due to use of Part Modules
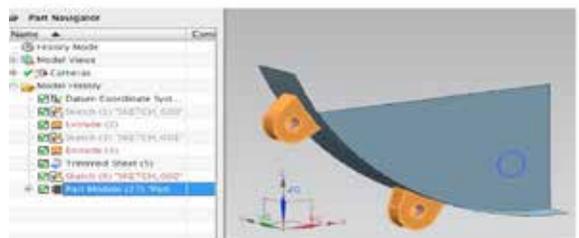
Body (11 and 12) to create the output bodies of corresponding

Linked Part Module. It is easier to spot the features from which a particular section of part is made up of when a part is less complex. But it is a lot more difficult when part is more complex, say an engine block. It also becomes trickier to understand feature dependencies and their parent- child relationship. Hence along with modular design and concurrent engineering capabilities, Part Module proves to be quite handy when it comes to reducing the part navigator cluster and understanding the feature dependencies better. In Figure 6, we can say that the brackets on main frame are created using feature Part Module (27).

CONCLUSION

The concept of Part Modules not only supports Modular Design approach, but it also helps in implementing Concurrent Engineering which can enable an organization to fast track the product design and product development phase. Many of today's higher end design tools have functionality allowing multiple team members to work on multiple parts of a same assembly; the same is not the case with a single part. With development of Part Modules, PLM industry can only go forward.

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