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think3's Product Configurator Powers Mass Customization

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think3's Product Configurator Powers Mass Customization

Allows development of the customization process without programming

Introduction

Last month we had the opportunity to meet with think3 executives and technical representatives to develop an understanding of think3's exciting thinkteam Product Configurator. This paper presents our findings.

Product Configurator, built on top of thinkteam, think3's product data management (PDM) offering, and also integrated with thinkdesign, think3's design authoring CAD system, provides a solution to companies that offer customized products in either a configure-to-order (CTO) or an engineer-to-order (ETO) model.

The business processes for delivering CTO or ETO products involves a combination of front office and back office processes. The front office sales processes capture the requirements of customers, followed by the generation of a custom proposal or quote. If the custom product configuration is accepted, back office processes can be initiated to produce engineering designs of the products to the specific customer requirements.

Companies offering such customized products frequently need heavy involvement of design engineering resources to produce proposals for the front office sales processes as well as new designs and information for engineering and manufacturing processes. This is necessary because such an order often calls for front end engineering analysis to select needed parts from families of similar parts in addition to designing new parts, all while understanding and melding these choices into the overall product engineering. For instance, emergency vehicles are usually custom ordered to the specific needs of the department. They might have requirements for size, capacity, sirens, and storage facilities for emergency equipment. In a large majority of cases most of these parts have already been designed and now need to be selected for this specific order. The engineering process determines which parts and assemblies are needed and whether any special designs need to be custom engineered. Often there are many shared parts and processes.

Without an automated product configuration capa-

bility, companies face challenges in their ability to generate accurate proposals and quotes rapidly, validate customer requirements, reduce cycle times for engineering and manufacturing, and be responsive to customer needs and schedules while controlling costs and quality. *In our estimation, the think3 Product Configurator meets this need.*

think3's Product Line

The think3 products relevant to this paper include thinkdesign, an advanced 3D modeling system; thinkteam, a product data management system; Product Configurator Manager, and Product Configurator Browser. The latter two will be explained in this paper.

Overview

Essentially, Product Configurator allows developing a catalog of product configuration models using

Product Configurator automates the processes for the engineering and manufacturing of customized and configurable products and components. The goal -- to provide the ability for enterprises to offer their customized products in a Configure-to-Order (CTO) manufacturing model or an Engineer-to-Order (ETO) design-to-manufacturing model.

Since each customer can configure products to match their individual needs, this is called mass customization. Other terms are often used for CTO, such as Assemble-to-Order or Build-to-Order. ETO is also often called design-to-order.

configuration rules, constraints, and data parameters that allow input data, after being entered, to produce a custom finished product. It can not only select alternative configuration options, but can also design new parts if one does not already exist that meets the desired criteria. *The beauty*

of think3's implementation is that no programming is needed to accomplish this. Authors use the Product Configurator Manager for developing product configuration master models, based on a virtual bill of materials, parameters and constraints or rules. End user clients use the Product Configurator Browser application to select input parameters, verify valid configurations, and to generate the configured product.

Customer benefits

Some examples of think3 customers using the Product Configurator in an engineer-to-order mode are manufacturers of elevators, hydraulic components, architectural and industrial panels, and industrial machinery. Their product portfolios involve a high degree of custom designs based on customer requirements, and thus lend themselves to achieving significant benefits from automating the product development process.

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Achievable benefits have included: a 90% reduction in cycle time for creation of new configurations per product family, a 75% reduction in resources to manage new part numbers and BOMs, the elimination of errors and costs due to invalid configurations, a 60% time reduction in generating sales proposals, as well as saving engineering time by automatic generation of models, drawings, and BOMs. The end results are faster cycle times, increased quality, reduced product development costs, and improved product documentation.

In one case, a think3 customer in Italy producing custom built elevators achieved dramatic results. Before using the think3 Product Configurator, this customer designed each of their systems using traditional CAD methodology. By using the think3 Product Configurator, they reduced their average custom engineering time from 6 hours to 0.5 hours (90%), reduced their BOM management time from 2 hours to 0.5 hours (75%), and reduced their product development cycle time from 2 months to 1 month (50%). For an output of 500 designs per year, this has resulted in significant cost savings with faster time-to-market, improved quality and increased customer satisfaction. Excellent payback!

Conclusions

We were very impressed with the capability of think3's Product Configurator. think3's mission is to provide integrated solutions to revolutionize the product development processes of mid-sized manufacturers; for this application they have really delivered. Not only is the application low cost, but also is the only product configuration application that delivers the results without programming.

Few competitors can offer such an easy to implement product configuration solution; none can match the low cost and flexibility that think3 offers. A possible alternative would be to use a KBE (knowledge based engineering) language, but this would be a difficult alternative requiring deep programming skills. Systems that use family tables would be another alternative, but with much more limited capabilities.

Companies developing or bidding on customized products based on variations of a basic design can benefit enormously from this type application and free up valuable engineering time for more innovative pursuits. In addition, they should be able to significantly reduce their turn around time since

these design variations can be produced virtually automatically once the design parameters are entered.

Once the user learns how to navigate think3's user interface, entry of the required rules and other data to perform complex custom configuration generation is straightforward. think3 expects to simplify the menu structure, which should be greatly improved for the next release. Some customers have implemented a step-by-step wizard for the client configuration process.

This application should prove useful not only to think3 customers, but to potential prospects as well. Getting started, even by users with competitive CAD systems, does not necessarily require a massive conversion. Instead, simply import the data related to the specific product to be engineered/configured to order. For instance, the virtual BOM capability makes it possible to import 2D AutoCAD drawings into thinkteam, which can then be managed by the PDM system and associated with part numbers. These part numbers can be used in the Product Configurator to develop the configuration model in the BOM. In this scenario, as the input parameters are selected to generate a configuration, the system can output a valid BOM, which references existing legacy AutoCAD drawings in the PDM database. This flexibility allows companies to begin the process of migration of legacy data while immediately deploying a configure-to-order process. Any engineer-to-order changes in the configuration would require that the components be designed in thinkdesign. One way to do this would be to utilize thinkdesign's excellent ability to import various types of 3D and 2D data.

In summary, we strongly recommend that users needing or considering configure-to-order or engineer-to-order solutions take a serious look at think3's offering. think3's Product Configurator is in a class by itself — offering powerful capabilities, easy deployment with little or no programming required, integration with other applications, support

by a knowledgeable professional services organization, and best of all — the price is right!

US pricing for authoring software starts at an annual subscription of \$8,285 including one seat each of thinkdesign, thinkteam and Product Configurator Manager. User software starts at an annual subscription of \$2,490 for one seat each of thinkteam and the Product Configurator Browser.

Configure-to-Order

The CTO approach allows customers to select from multiple product options, which then automatically generates a customized BOM for the manufacture of the custom configured product (for example – to order a laptop custom configuration).

Engineer-to-Order

The ETO approach, different than the CTO model above, allows customers to select from a combination of multiple design engineering variables and product options, which, when completed, automatically generates a new engineering product assembly design and its customized bill-of-material (BOM) for the manufacture of the custom configured product (as in the hydraulic cylinder design discussed in this article). In the ETO model, existing components are reused where available; new components are automatically designed, resulting in the automatic generation of the 3D models, 2D drawings, and the BOM for manufacturing.

Using the Product Configurator

Starting with the Product Configuration Browser

To demonstrate what this Product Configuration technology can do, we viewed a series of demonstrations using Version 8.2. Version 8.4 was released shortly thereafter and is the currently released software.

To assist the reader, we have placed larger images of the Figures and a description of each on our website at:

<http://www.technicom.com/think3/index.html>

These images illustrate the process of using the Product Configurator Browser and the Product Configurator Manager. Additional images and descriptions are at this location as well. The figure numbers used in this paper reference the figure numbers on the website.

We started thinkdesign and within the tools sub-menu of thinkdesign selected the Product Configurator sub-menu, which allows us to initiate either the Product Configurator Browser or the Product Configurator Manager. We chose the Product Configurator Browser. When using the Product Configurator Browser, we are asked to input the data for a previously developed configuration. The rules, constraints, and parameters have already been entered using the Product Configurator Manager.

When we open the thinkdesign Product Configurator Browser, we see which configurable products are available for use to develop a custom design. In our case, we have only one -- a double acting hydraulic cylinder.

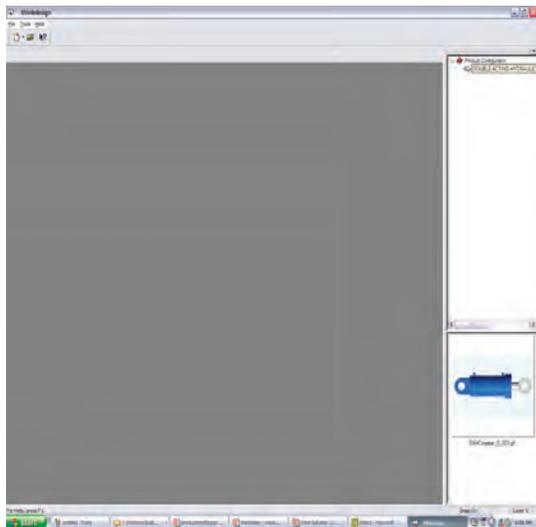


Fig. 1 - The Product Configurator catalog tree

Double clicking on this part family displays the alternative configurations. In our example we had 8 specific configurations that were previously gener-

ated. Associated with each configuration are a number of requirements or defining parameters.

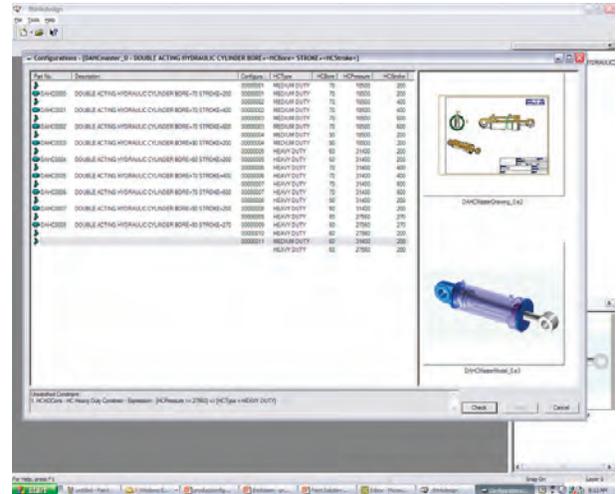


Fig. 2 - Input parameters for a configuration model

As can be seen in the above image, these requirements are: hydraulic cylinder type, bore diameter, pressure, and stroke length. Some configurations with certain combinations of variables have already been generated and stored. Thus they already have part numbers assigned. If we want to create a new configuration we just double click, assign a new configuration number manually, and then fill in the required input parameters. During the creation process we have the opportunity to check that the input values satisfy the constraints and rules for a valid design configuration. This validation check is based upon the parameters, constraints and rules defined during the creation of the configuration master model. If the input value check fails, a message informs us to correct the input parameters.

After entering the new parameters, which in turn creates a new configuration, we have the option to create a bill of material and the 3D model. The model consists of parts and drawings. During the computation, the system looks for previously designed parts with the same parameters that can be reused to develop this configuration. The system will build a new part if unable to find an existing part to reuse. To do so, the system uses a master template for a part (which has been pre-defined in the Manager) to create a new part 3D model. A master template can also exist for drawings, which are automatically generated as well.

When data entry is complete, initiating the command "Show Model" recomputes the model. The result, in this case, is an assembly of parts. The system changes the individual history trees of every part in the assembly, eventually developing the final assembly with about a dozen parts for this latest unique configuration of the hydraulic cylinder.

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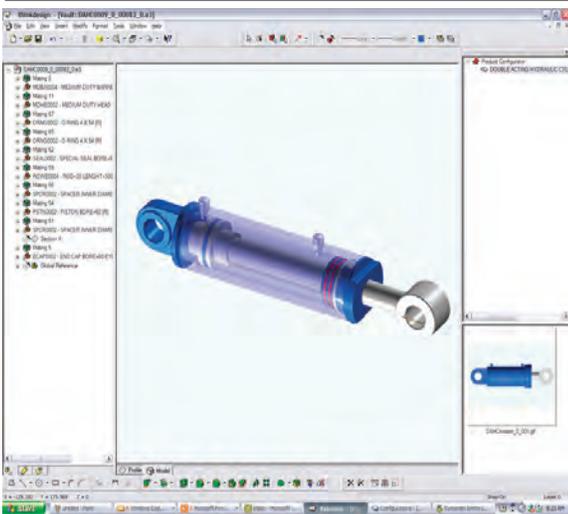


Fig. 4 - 3D model generated for a selected configuration

Note in Fig. 4 that the history tree of this model has been modified to meet the parameters we entered above.

The calculation of this model took less than a minute. While we have no metrics from think3, we observed a model of about 200 parts complete in less than two minutes. Obviously this time is primarily proportional to CPU compute capability. A faster graphics card and a faster processor would be extremely important to the recalculation times.

Developing a new configuration project using the Product Configurator

We investigated what it took to put together a new project, managing the new data that went into it, and then populating that.

First we opened up thinkdesign so that we could analyze and review the files that we had stored on our local workspace and file system. Alternatively, we could also have developed a new configuration using data stored in thinkteam PDM. We opened up a file and decided that it needed to be part of the new project. Using the menu item "Tools - Project Browser" we could browse the thinkteam database for existing projects and/or build a new project. The Project Browser (not to be confused with the Product Configurator browser) allows users to organize, view and build new projects for efficient organization and document management. The Project Browser is also available to thinkdesign users for document management when not using thinkteam PDM.

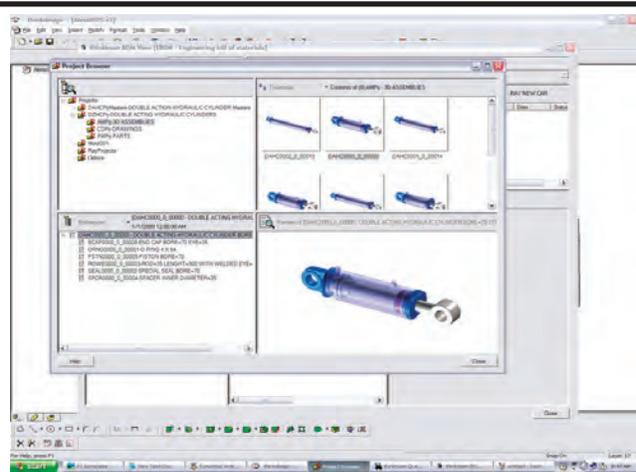


Fig. 14 - Graphical browsing capabilities of the Project Browser

For a project, we can view all of its related documents using the thinkteam Project Browser (included with every thinkdesign or thinkteam license for browsing the thinkteam files). Fig. 14 above is that of a project browser window depicting a typical project folder showing thumbnail images of the project folder contents and a preview panel for the document selected. Saving to a project is simple. Instead of a normal file save to the local drive, the users saves into a thinkteam project along with attributes (or metadata) describing the model.

Flexibility of working only from Bill of Materials

One alternative, and an excellent method when starting a new design, is to organize a new project from a bill of material (BOM) point of view. If the overall structure is known, then we can choose to enter a bill of material before detailed geometry or part numbers are available. Later we can assign part numbers to the bill of material. This allows the parts to be automatically inserted into the proper place in the product structure.

Building a new car virtual BOM

To test out the capabilities we decided to build a virtual bill of material (VBOM) for a car using only thinkteam. We used the "Insert - New Entity" from the top tool bar in thinkteam. We then chose "Part". The part sub-menu item allowed us to enter a new part number description and fill out the standard information for new part numbers. The BOM view (Fig. 18) allows us to view the product structure. From here we can assign new part numbers. To test its ease of use, we assigned part numbers for an engine, wheel, drive train, etc. We are easily able to assign part numbers and readily developed a bill of material without any geometric elements. The really interesting part is that, as we define geometry later, we can link it to a pre-existing VBOM part number, so it properly appears in the correct place in the project BOM.

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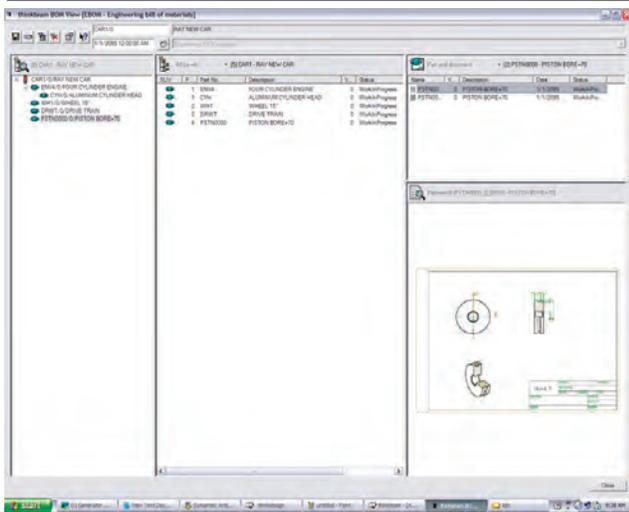


Fig. 18 - Product structure / BOM view

Creating a new product configuration master model

To setup a new product configuration we use the Product Configurator Manager. First we define the master. Then within each master we are able to organize parameters, constraints and bills of material.

First we determined the required parameters of the eventual configuration. In our particular case, we had:

- type of hydraulic cylinder
- bore diameter
- operating pressure
- stroke length

For each parameter, we need to organize the types of values that are allowable as valid input. Input options include closed sets (requiring the user to select from a predetermined list of choices), open sets (where the user can select from choices or key in a new value), or restricting input values to a pre-determined range. Values can be real, integer, string, etc. Then a series of constraints (equations) define the inter-relationship between various parameters. This is used to validate whether the input parameter values are correct in the Product Configurator Browser.

Optionally, the engineer can also develop a series of scripts, which are equational relationships that allow the calculation of parameters that will eventually be fed into the geometric formulae. One example might be to use the original parameters to calculate maximum load. The maximum load can be used as an input parameter into other equations, relationships, scripts etc.

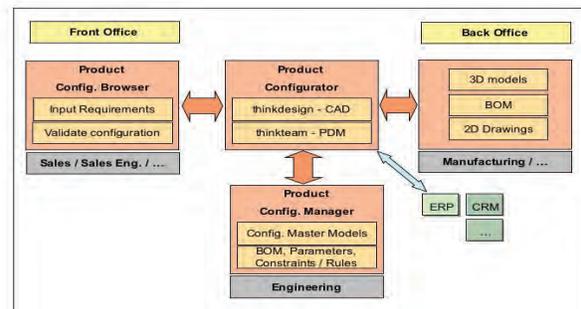
Next, we need a virtual bill of material, which will eventually allow the development of the geometric entities involved in this configuration. We have three options in creating elements of the BOM structure: part, variant, or master. The part option uses an existing part from the database. The variant option allows the selection of one part from a choice of multiple options; the part selected being

determined on the satisfaction of a specific constraint or rule. The master option allows the use of other component configuration master models within the BOM, thus allowing a hierarchical structure of configurable components or sub-assemblies.

The eventual output is the creation of a bill of material for the final product once the configuration parameters are entered. In our case, as an example of a variant, if we select a medium duty cylinder type, the Product Configurator changes the matching cylinder head type, a different barrel type, its matching bolt holes, and other mounting options for the medium duty rating. After the definition of the parameters, constraints and bill of materials, the definition of the master product configuration model is complete.

Integrating the proposal through delivery process

The figure below shows how think3 Product Configurator provides a solution to integrate the front office sales processes with the back office



engineering and manufacturing processes. Using Product Configurator, Engineering can develop product configuration master models, which can then be used by the front office sales processes to input customer requirements and verify valid product configurations. At the same time, the configuration model will generate the required custom BOM, 3D models and 2D drawings and documentation for the back office manufacturing processes. This automated process improves turnaround time, accuracy and responsiveness of the front office sales processes. Engineering is taken off the critical path of the proposal-to-delivery process, resulting in faster cycle times, improved part reuse, reduced costs and increased quality.

How to get started

Does it fit?

After determining what products or product lines are amenable to automated ordering and configurable design, a first step would be to implement thinkdesign and thinkteam, thus getting started on developing or importing any required geometry.

The next step would be to carefully evaluate how to go about the configuration process. This means taking a look at repetitive design processes and figuring out what portions can be designed using a configuration model with parameters, constraints, and rules.

The next step would be to develop a master configuration model, which contains these rules, parameters, and constraints. The same master configuration model provides the “smarts” to output models, 3D parts, and 2D drawings if needed, as well as the BOM.

Leverage existing data

The Product Configurator can leverage existing engineering data, while beginning to deploy a configure-to-order product delivery process. The virtual BOM capability makes it possible to import 2D AutoCAD drawings (for example) into thinkteam PDM, which can then be managed by the PDM system and associated with part numbers. These part numbers can be used in the Product Configurator to develop the configuration model in the BOM. In this scenario, as the input parameters are selected to generate a configuration, the system can output a valid BOM, which references existing legacy AutoCAD drawings in the PDM database. This flexibility allows companies to begin the process of migration of legacy data while immediately deploying a configure-to-order process. Any engineer-to-order type engineering model and drawing changes in the configuration would require that the components be designed in thinkdesign.

Consider using think3 Professional Services

think3's Professional Service Organization can assist either new or existing customers to get started. A typical starter assignment could be as short as 2-3 days for training and installation, plus 1 day for user training. The work effort, and any follow on user effort, will depend on the business rules and configurations, the complexity of the product structure, the skill of the persons using the configurator, and any need for a custom interface, such as to a BOM or ERP system.

For more information

See our conclusions above; review the Appendix below; contact think3 at www.think3.com.

APPENDIX

A detailed demonstration reveals more about the simplicity of developing custom configuration models

On our second visit with think3 we worked with their technical representatives to understand in more detail how the system works. We looked at a simple mount assembly and a more complicated electrical enclosure assembly. We think it is worthwhile sharing this with you. Larger images are available at <http://www.technicom.com/think3>.

Simple Mount Assembly

Defining the configuration model

In this example, the mount assembly consists of a mating block and a pin component. The configuration requirements are that one of several different types of pins is selected for use in the assembly, based on input requirements for a tensile strength attribute. The configuration model virtual BOM for the mount assembly therefore consists of a fixed part (the block) and a variant that allows for the selection of one pin component from multiple available choices.

Steps to creating a configuration model

- Create the master configuration (top level)
- Create the virtual BOM structure – parts, variants, masters
- Create the 3D CAD assembly templates for 3D models and 2D Drawings
- Link the CAD assembly components to the virtual BOM entities
- Define the configurator parameters
- Define the configurator constraints or rules that are used to create multiple configurations

Authoring with the Product Configurator Manager

To define the configuration model we start by creating the master configuration for the assembly, which is the top level (or root) of the virtual BOM (VBOM) structure. We then insert the block component into the virtual BOM as a part, since the block is common to all assembly configurations. To

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be able to select from a choice of pin components, we then insert a pin variant into the VBOM, and define 2 separate pin parts as the variant choices (colors gray and yellow). This variant component in the virtual BOM will be used to select from one of the pin components based on the parameters and constraints, as shown in Fig. A2.

To link the configuration VBOM defined in the Product Configurator Manager with a thinkdesign 3D assembly model, we use thinkdesign to create the 3D mount assembly and store it into the thinkteam database along with metadata with non-geometric part information. This involves creating a 3D assembly with the block component and pin component, using symbolic references to mate the block and pin, followed by storing the components and assembly into the thinkteam database with its metadata.

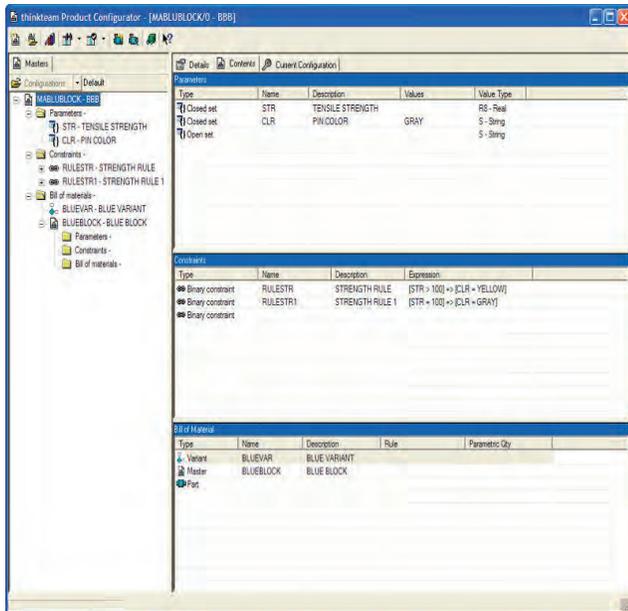


Fig. A1 - The master configuration details in the graphical user interface of the Product Configurator Manager, with the associated configuration parameters, constraints or rules, and the BOM. The individual panels for Parameters, Constraints and Bill of Materials show details such as the type of parameters and their values, the constraints that use these parameters, and the BOM structure.

Symbolic Referencing allows one mating part to be replaced by another mating part (as in the pin example) and still be correctly mated in the final assembly. Basically this involves using the same naming convention among mating features so that the resulting mating constraints will still execute correctly upon replacement of the original part.

A powerful capability of the Product Configurator is the flexibility to either first define the configuration master model (VBOM, parameters, constraints), and then link it to 3D CAD models and drawing templates later, or vice-versa. This flexibility also

allows companies to use existing CAD assemblies to develop new configurable products, without having to recreate any new CAD models.

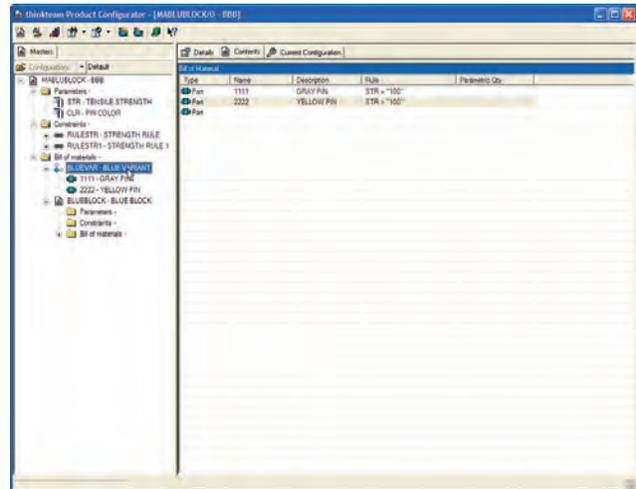


Fig. A2 - The BOM with a Variant selected in the configuration model, and also shows the part details for the possible variant selections based on the rules defined.

After the virtual BOM is defined for the master configuration, we also define two parameters for tensile strength and color, while defining constraints that select a pin of color yellow or color gray based on the value of the tensile strength parameter. Figure A1 shows the BOM, parameters and constraints for the configuration as defined above.

Fig. A3 shows the details of a part selected in the virtual BOM.

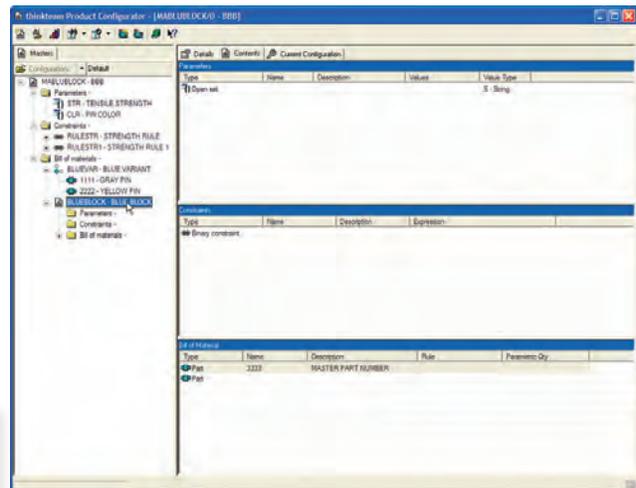


Fig. A3 - The BOM with a Master selected in the configuration model, and shows the attribute details in the BOM panel.

Configuration model verification

The Product Configurator Manager application provides several methods to verify and check the master configuration model, including the ability to check variants, constraints and parameters. These next two images illustrate some of the possible con-

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figuration checks used to verify that the configuration model has been properly setup and defined.

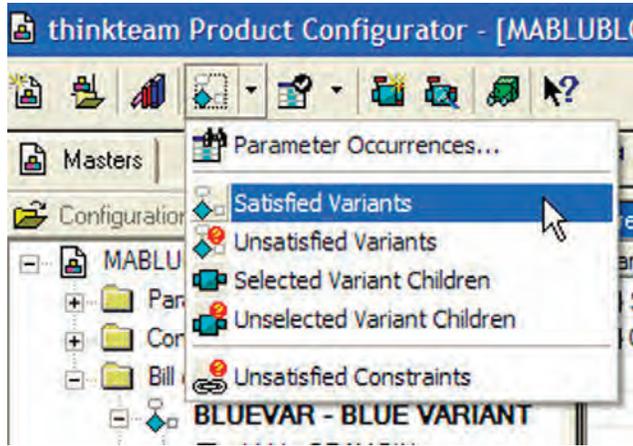


Fig. A4 - The Variant verification menu in the Product Configurator Manager that allows a user to verify the configuration model based on the parameters and constraints.

Using the Product Configurator Browser to generate assembly configurations

The steps described above primarily concern authoring using the Product Configurator Manager to define the master configuration model. Below are two examples using the Product Configurator Browser to input requirements to generate different output configurations. The following two figures show how we generate the different product configurations by entering the two required inputs - strength and color. The process to produce the end product then uses the master configuration model that has previously been defined with rules, parameters and constraints.

The following figures show menus available to generate the BOM or the 3D model for the configuration selected, while taking into account factors such as part release status and effectivity date.

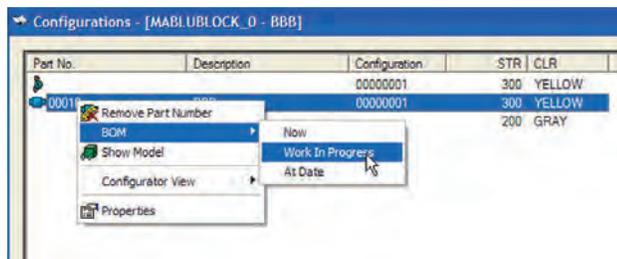


Fig. A6 - The menu options to generate a BOM for the configuration selected based on the part status or effectivity date.

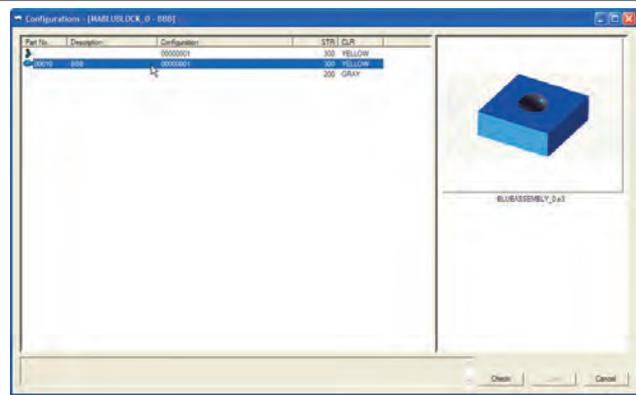


Fig. A7 - A list of the configurations for the current model with a preview of the configuration assembly selected.

Electrical Enclosure Assembly

What follows is an excellent example of a moderately complex product configuration - a sheet metal enclosure. The image below shows the master configuration model for the enclosure, with the virtual BOM in the left panel showing the parameters, constraints and BOM. The individual panels on the right show detailed information on the parameters in the top panel, the constraints or rules defined in the middle panel, and the BOM in the bottom panel. Note that while the parameters and constraints are defined by the user interface, these can also be defined using Visual Basic, which provides an extraordinarily flexible and powerful programming capability, readily usable by an engineer.

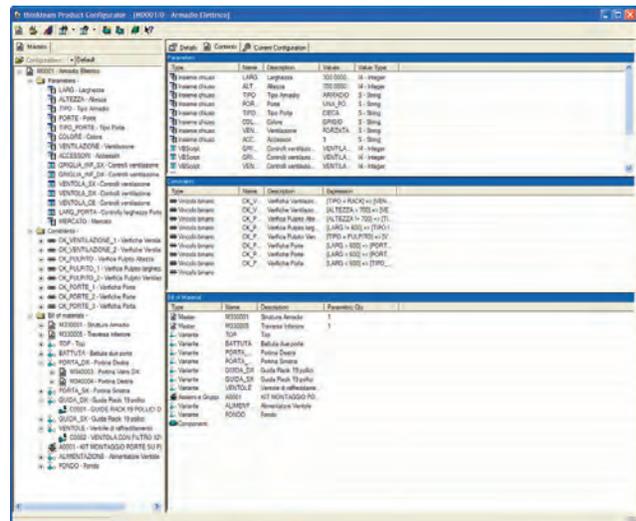


Fig. A8 - The Product Configurator Manager view of the configuration model for a Sheet Metal Electrical Enclosure assembly, with the parameters, constraints and BOM.

The image below illustrates how the parameters are chosen to check and create a new configuration. The display list also shows all existing configuration combinations. In the next to the last line note that the parameters for the new custom configuration have been entered.

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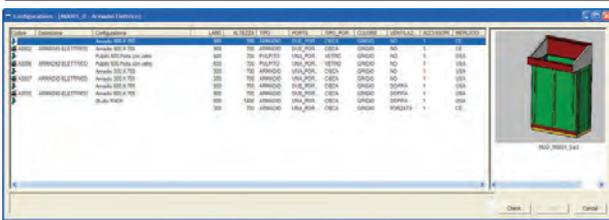


Fig. A9 - The Product Configurator Browser window with the various configurations and a preview of the selected configuration of the Sheet Metal Electrical Enclosure assembly.

The following image shows the product configuration 3D assembly that was created as a result of the new configuration created with the specific parameters in the previous step. Notice the new doors with slots and the new top cover.

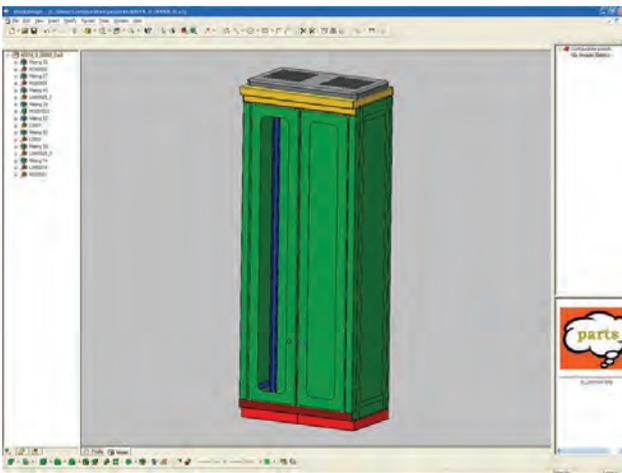


Fig. A10 - The final 3D assembly model that was generated for a new configuration of the Sheet Metal Electrical Enclosure.

The final model with its product structure, its BOM,

a view of the configuration and its related documents, are all generated automatically. See Fig. A11.

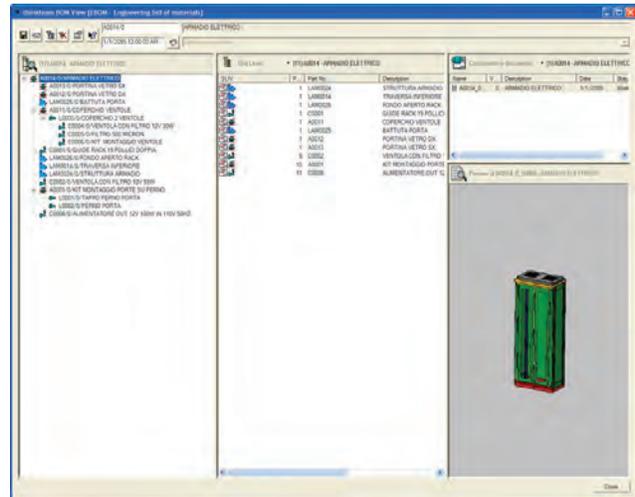


Fig. A11 - The BOM view for the configuration generated along with the associated documents per part and a preview of the selected item.

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