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Solid Edge with synchronous technology changes solid modeling:

A review of the Solid Edge implementation of Siemens synchronous technology

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Executive summary

Introduction to this paper

In April, 2008 I had the unique privilege of visiting Solid Edge headquarters in Huntsville, Alabama to view one of the first external presentations of the new version of Solid Edge using synchronous technology. In the day and a half that I crawled through the software demos, I was blown away by the technology and its ramifications.

Summary of the technology

Siemens PLM Software has been working on direct face modeling in Solid Edge for several years. The culmination of some of that experience has resulted in this dramatic new paradigm called Synchronous Technology. They have taken direct modeling many steps further and are able to operate directly on the 3D model. While other CAD software perform direct editing, Solid Edge's unique implementation combines the speed and flexibility of direct modeling, yet it adds the modification control aspects of constraint based modeling; users can add and lock constraints when needed to precisely control how the model changes.

Background on modeling

Solid Edge's new synchronous technology involves the complete replacement of history based modeling (aka – parametric modeling) with a new paradigm – direct modeling plus features. Some readers will mistakenly equate Solid Edge synchronous technology to existing "explicit" modeling systems. This could not be further from the truth. Prior to the introduction of Solid Edge synchronous technology no explicit modeling system offered all the following aspects in a single system: constraint solvers in 2D and 3D, locking of dimensions to control the position of geometry, detailed control of how selected objects move (Live Rules), equation relationships between dimensions, "feature-like" edits beyond simple patterns, parameterized control for basic mechanical features like holes, and a feature collection to delete operations or select geometry using a single operation.

Solid Edge's synchronous technology introduces the following key technologies, discussed in detail later in this paper):

- History free, feature based modeling
- Live Rules
- Procedural features
- 3D driving dimensions
- Synchronous solve

All leading to an unmatched user experience.

Prior explicit modeling systems have usually exhibited only one of these technologies – direct modeling. *What gives Solid Edge synchronous technology its power and makes it a breakthrough technology is the combination of these technologies.*

How synchronous technology works and what makes it different

At the heart of the system and where the name was derived, Synchronous Solve, uniquely manages the entire edit process. When the user executes a drag or dimensional edit, the system takes into account: existing geometric conditions, user defined formulas and equations from the variable table, procedural features (such as rounds, patterns, thin walls, holes), explicitly defined constraints, and 3D driving dimensions. The geometric solver further detects and attempts to maintain, at the users discretion, the geometric relationships of parallelism, concentricity, tangency, and coplanarity -- all automatically, with no intervention by the user. Whether constraints are explicitly defined or omitted completely, common geometric conditions are found and maintained automatically with Live Rules. We'll discuss this more later. This is critical to understand how synchronous technology works.

Conclusions

I have not seen anything as exciting and innovative as Solid Edge with synchronous technology since the introduction of parametric modeling in the late 80's. Solid Edge with synchronous technology offers a dramatic breakthrough by combining direct modeling, parametric modeling, and a new user interface. Siemens PLM Software has rethought how users can more easily model in 3D. Users should love how easy it is to build and edit models - all without any need to pre-plan how models might be used in the future. Solid Edge's competitors will be scrambling for years to catch-up.

Capturing ideas within Solid Edge synchronous technology can result in a faster design process, the result being a completed design in significantly less time than a history-based CAD system. Not needing traditional history-based relationships results in building initial designs faster, and even more important, since most designs are an iterative process, not needing complex history-based relationships makes editing designs easier, resulting in an shorter overall design process.

We expect that benefits to users will accrue in faster model creation and editing, in simplified ease of use, and in a dramatically easier way to work with imported data.

A more comprehensive discussion of our conclusions can be found at the end of this paper.

Do not hesitate! As soon as you can get a copy of Solid Edge synchronous technology we recommend you do so. Evaluate for yourself how easy it is to build new models, how easy it is to edit existing models, and how easy it is to import models from virtually any system that can translate to the Parasolid format (virtually all CAD systems). Invest the money to buy a few seats and train one or two users. Then compare the results logically and without emotion to your existing techniques. I would like to know your results. Write to me at rayk@technicom.com.

Synchronous modeling technology details

A history-based modeling primer

Starting a design

History-based solid modeling systems generally start by defining a sketch and then extruding the sketch into 3D. Users then operate on the extruded shape using so-called features. Each modification to the design is saved by sequentially storing each change in the sequence it was made. Thus, the term history-based modeling. Each feature added relies upon its being at a specific place in the history, because it may depend upon a parameter developed or used by a feature which preceded it. This is particularly true for fillets and thin-wall features.

The history tree – the good and the bad

The history (often called a history tree) offers users a powerful way to change the resulting model. Users can simply change any of the historical events that produced the resultant model and re-run or regenerate the model by replaying the history. Unfortunately, this power comes at a stiff price. If edits or changes to the model are made, in many cases, the users must go back to the feature or the original 2D sketch of a profile, changing it as needed. Features typically have a number of options when added to the model, such as through or blind holes, attachment points, size, relationships to other features or the model, orientation, etc. Changing features or sketches require replaying the history from the point of the change. This works well in simple models (with less than 100 items in the history tree) because it is fast and easy to visualize how to edit a model to make the appropriate changes. For larger models and assemblies of parts, the difficulty of determining what to change and the time it takes to regenerate the changed model often limit the power of history-based modeling. To their credit, CAD vendors have initiated a number of improvements that limit the need to regenerate the entire model, such as history tree re-ordering. Nevertheless, editing of existing models seems to require a user with exceptional skills and lots of time, especially if he edits another persons model.

For example, PTC's Pro/ENGINEER, the progenitor of history based systems, uses the notion of a feature-based 'parametric' system. Subsequent geometry is built upon and references geometry that occurred before it. All geometries are controlled by parameters, which comprise constraints and relationships. Constraints are variables such as part dimensions and equations. Relationships generally refer to parallelism, perpendicularity, concentric, etc. As a user works, the software builds a feature history tree, which tracks all relationships and parameters and stores the order in which users create features. The tree effectively serves as a part "recipe." Changing a step and replaying the recipe forces associations in the history tree to ripple through the model and "regenerate" the new part. Once a part is built, users need only type in variables to change a preprogrammed model. [1]

History tree complexity

Because history-based models record a history of the operations required to build the model, there is a high degree of complexity involved in altering the model. Often, seemingly minor changes to the model result in excessive compute times because the model has to recalculate its entire history. History-based solid models have another serious drawback, resulting from the architecture – models are often difficult, if not impossible, to edit, because one needs to first understand the existing history. Complex models are often

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[1] "Comparing 3D CAD modelers", by Leslie Gordon, Machine Design, 22 Nov 2006

“dumbed down,” meaning that their history is eliminated before being modified. Unfortunately, this also eliminates the advantage of history-based modeling.

Design Features

Feature-based modelers allow operations such as creating holes, fillets, chamfers, bosses, and pockets to be associated with specific edges and faces. When the edges or faces move because of a regeneration, the feature operation moves along with it, keeping the original relationships, if possible.

About synchronous technology

Solid Edge with synchronous technology differs significantly from traditional CAD systems – both the parametric (history-based) and explicit varieties. In today’s market, the leading mechanical CAD systems are history-based solid modeling systems. A few others are explicit modelers which directly alter the solid model and keep no history (a record of the operations performed on the model). Some history based system also a limited amount of direct editing of the model as well and generally retain such edits as part of the model history.

Solid Edge with synchronous technology eliminates the history-based requirement that traditional CAD systems have and replaces it with a dramatically new operating environment. Using synchronous technology promotes a new interactive design environment that it is simpler to operate and allows faster modeling. Changes made after the initial model design (editing) are substantially easier than history-based CAD because users are not bound by a rigid predefined definition of the model. Therefore, designs can be iterated faster. Another integral aspect of synchronous technology is the automatic recognition of geometry relationships within the model. We will discuss this later. Solid Edge contends that we can now harness the power of 3D with the simplicity of 2D. While perhaps a slight oversimplification, we believe synchronous technology comes closer to this than any prior system!

Planar sketching starts or adds to the model

One of the things that makes this possible is sophisticated face inference sketching. Users can now sketch directly on a face much easier, and there are no specific requirements in terms of the sketching on that particular face. The inference logic that normally applies to 2D is now carried over to 3D, which proves particularly useful for constraining the sketch to other points on the model. These sketch constraints are not required later because, as we’ll see, Live Rules controls the manipulation of the model thereafter. One key aspect to synchronous technology is the ability to directly modify geometry on the fly; users can make changes to a face, a set of faces, or an edge, such that these elements can be rotated, moved, manipulated or changed. Directions of the change are controlled by selecting the elements of the “steering wheel.”

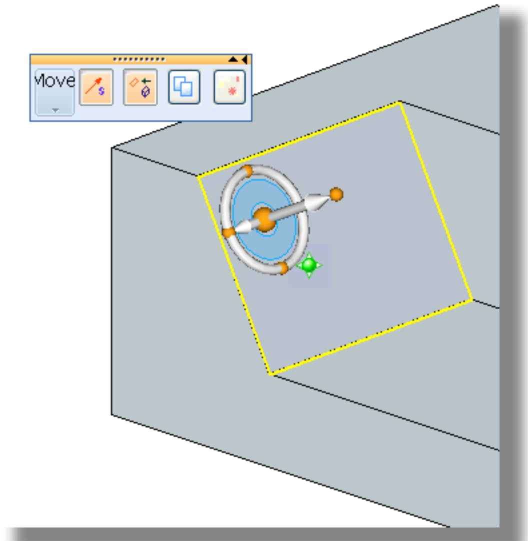

Image 1: The steering wheel. Choosing the orange selection points controls the modification type.

The steering wheel manipulates geometry

The steering wheel allows one to make substantial modifications in these geometric elements, including: drag to move, rotate to add taper, select direction of move, and align to geometry for precise directional control. A key aspect is that it makes changes directly on the element selected. Face selection also provides a pathway to a Selection Manager that helps choose geometry by function such as ribs/bosses or cutouts. Other conditions the tool finds are parallel, equal radius and many more.

Sketching on a face and its significance

Direct sketching on a face allows reducing the need for establishing relationships, but have total control of design optimization "on demand." One example is: why use design features for bosses and pockets when they are not needed? Simply draw a sketch on an appropriate face and remove or add material. It's faster and simpler, and eliminates unneeded design steps. To edit one of these, modify the design directly instead.

Procedural features add the power of features when most needed

There are a number of procedural features that are used in synchronous technology. They are holes, thin walls, rounds and patterns. In the case of a thin wall procedural feature, Solid Edge with synchronous technology allows the thin wall to be computed at any point in time. In history-based modeling thin wall features are extremely sensitive to their location in the history tree. Placed too early or too late produces the incorrect result. In Solid Edge instead, the thin wall feature includes tools to simply attach and detach elements of the model (to the feature) that promotes directly developing the correct thin wall during the thin wall design process. Solid Edge with synchronous technology can run multiple thin walling operations on a model at various points in time. Traditional systems require that one and only one thin walling operation can be done so the model has to be carefully built to allow all features to participate in that thin wall. Subsequent operations would not work in that thin wall. Synchronous technology allows you to thin-wall a model at any point in time with additional thin-walling operations to cover features that weren't originally thin-walled.

Holes, another good example of procedural features, can be placed using parameters (such as size, type, depth, threads) and retain the ability to use those parameters to edit the hole type.

Importantly, changes to procedural features only cause a regeneration of related geometry. A classic problem procedural features solves is that when editing features like holes created early in the design process, subsequent geometry need not be regenerated unless it's related. Such "searching out related geometry" promises the ability to edit the first operation as fast as the last, while still allowing parameter edits.

Live Rules

Live Rules allows automatic recognition of relationships and maintains them throughout an edit—even if there were no defined rules. Many geometric conditions are "obvious" to a user, but since traditional CAD systems don't understand this, relationships must be defined to maintain those conditions. For example, tangencies should almost never be broken, so why burden the user and system enforcing this? Other strong geometric conditions include concentricities, co-planar, symmetric, and horizontal or vertical. Live Rules finds and maintains these conditions during edits. Users have the ability to add or remove conditions to get more specific results.

Some of the options performed by the inference engine are shown below in the dialog box.

Image 2: Live Rules dialog box

This becomes extremely important in direct modeling, allowing changes to groups of elements than can be operated upon, en masse.

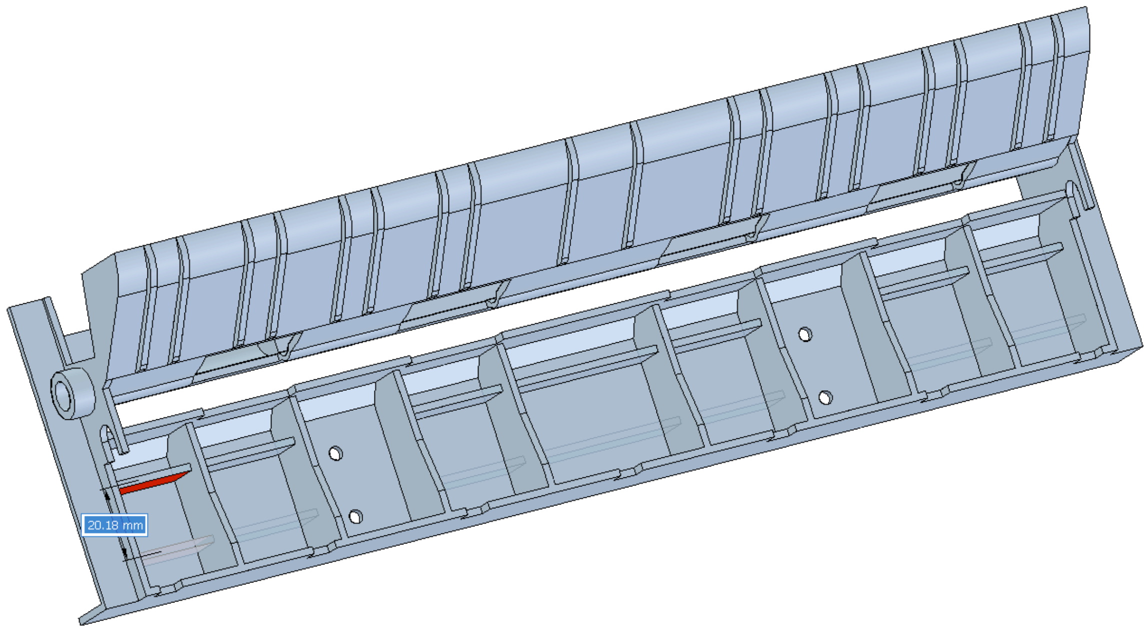

Image 3

For instance, the image above shows an imported model where the original intent was to keep the supports that span the width on the same plane. Because this relationship was lost in translation, Live Rules finds all co-planar faces upon selection of the face shown in red. With a single face select and move, the entire series of ribs will move.

Live Rules in combination with the fact that features are not dependent on each other has powerful implications. Users using Solid Edge can move a hole and actually drive the underlying geometry as managed by Live Rules. Similarly, the underlying geometry can be modified also repositioning the hole. Editing either the mounting holes or outermost faces of a pillow block is a practical example.

3D Dimensions (locked and driving)

Traditionally, dimensional editing of the 3D model primarily used dimensions originally developed in 2D sketches and parameters that were added by the features. In Solid Edge, dimensions are directly applied to the 3D model and the model can be altered directly using those 3D dimensions. In the image below we show a dimensioned part. Note that the dimensions are in the 3D model and that they are easy to interpret. Changing any of these dimensions changes the part! How easy could that be? No history to evaluate. No features to interpret. When the feature is placed during its construction is meaningless.

Dimensions are available with 3 different capabilities. The first are dynamic 3D driving dimensions, shown in blue. These allow edits by the user and can be changed by external edits such as face moves. In this example the 1.25 dimension at the base will increase should the leftmost face be moved. The second type are fixed 3D dimensions. These too allow direct edits by the user but lock out external changes. Should that same 1.25 dimension be modified, the 1.000 width of the base will be kept. The last type are equation-based 3D driving dimensions. This type will only allow changes, from some other dimension. The hole will remain centered on the base because of the formula shown in the Variable Table.

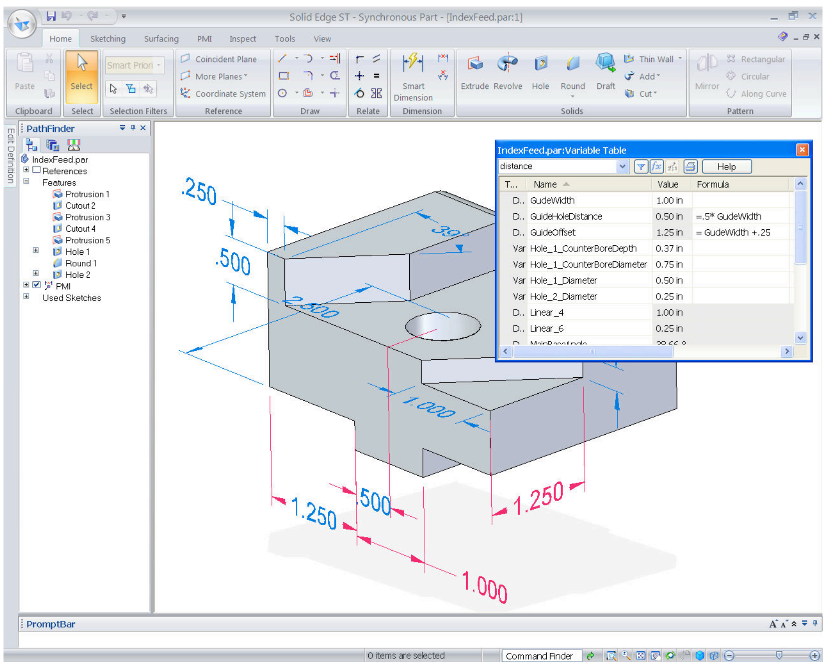

Image 4

The selection manager controls the selection of geometry, allowing Solid Edge synchronous technology precise control over changes. Note in the image below, how the cutout moves to different parts of the model, automatically inferring needed changes to produce the correct geometry.

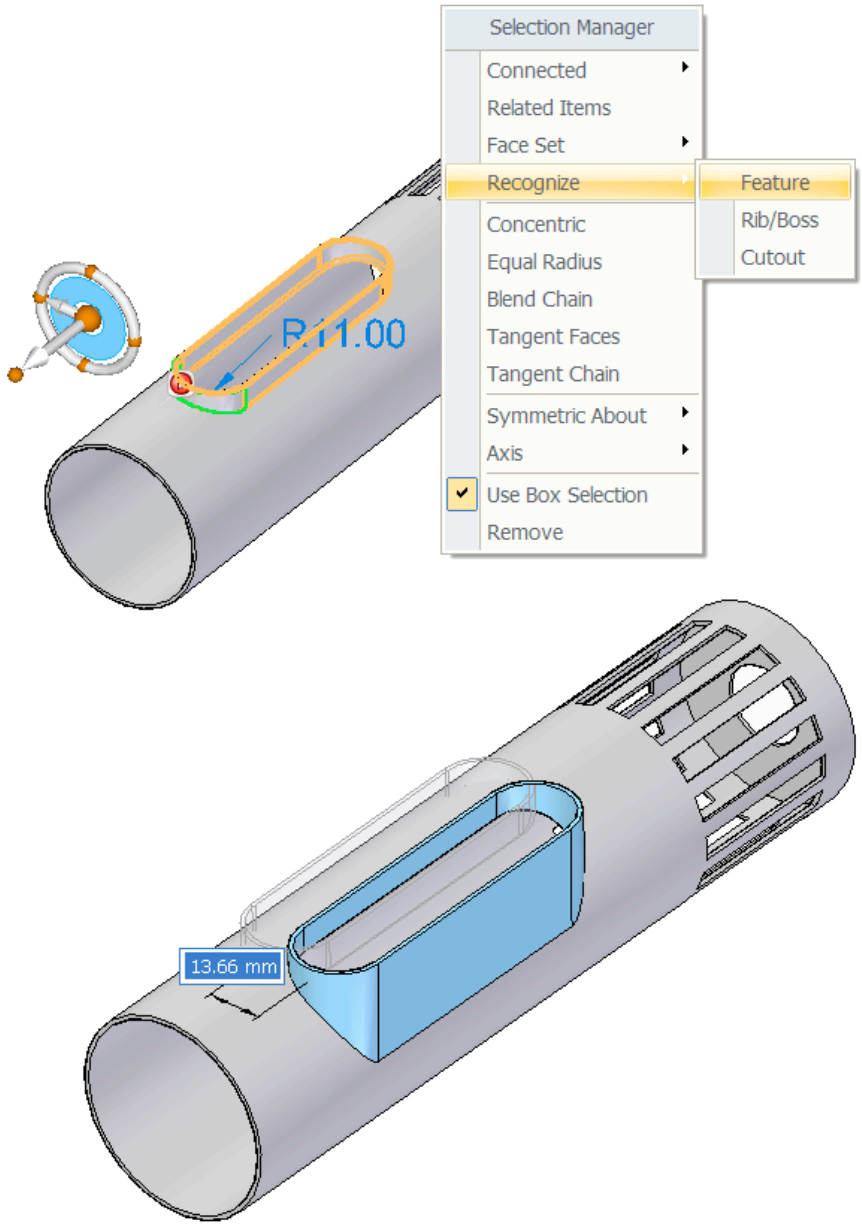

Image 5

Want to establish equational relations between parameters? Use the variable table to enter user defined formulas and equations.

Some examples of synchronous technology at work

Shaft link

Look at the part modification below, Image 6. It was changed by selecting the radius of the outer diameter and moving it to the right. The concentric relationship of the hole was automatically recognized because that relationship was found by Live Rules. While the edit may appear to be simple. The complexity is in the connected tapered faces which must remain tangent to the boss cylinder as the hole is moved.

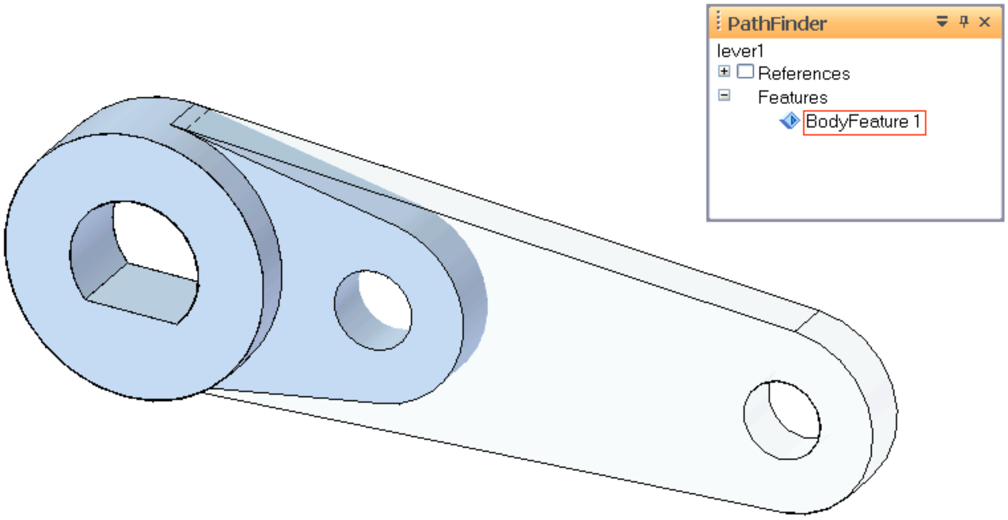

Image 6

A thin wall part

The images below depict an example of a plastic, thin walled part with a number of features hidden behind the part that are support for the model.

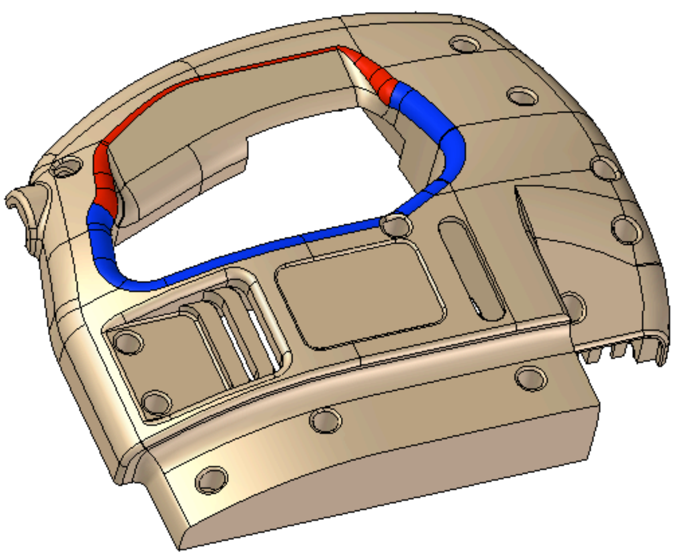

Image 7: plastic thinwall part-front

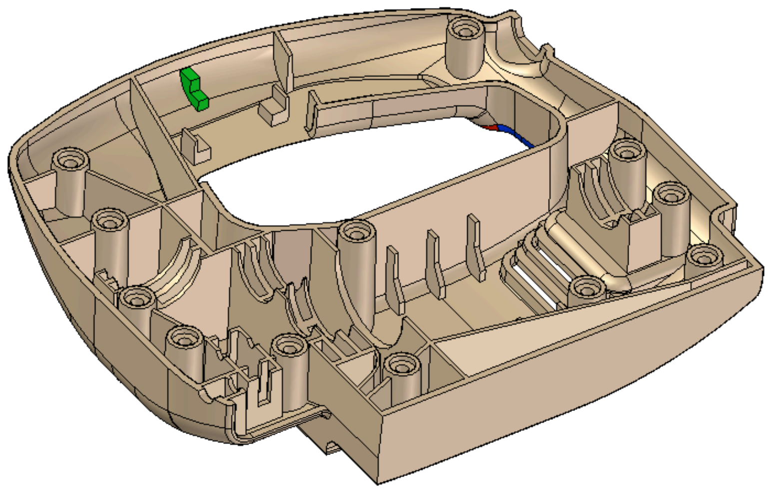

Image 8: Reverse side of plastic thin wall part with lots of features

This saber saw part might have hundreds of features. In a traditional modeling system making a slight change such as the radius of the blend on the outer structure (shown in red and blue in Image 8) probably would cause a complete regeneration of the part. In the previous version of Solid Edge, with non synchronous technology, this change takes 51 seconds to regenerate. In Solid Edge synchronous technology the same operation takes 2 seconds. This does not even count the engineering time dedicated to deciding how to make changes, Nor does it consider the ease of use of not needing to be concerned about the history and procedures used in the original model.

An intrinsic capability of Solid Edge with synchronous technology is the ability to do *localized compute*. That is, Solid Edge only re-computes changes to elements within the model that require it, rather than regenerating every element that succeeded the changed element. In addition to saving on regeneration time, engineers now can free themselves from concern about how to change existing models. No longer is there a need to spend design time analyzing out what needs changing and how best to make the change so that he gets the desired result. This goes away with synchronous technology.

Important dimensions and parameters are captured as needed, not all of the constraints that comprise the model. This differs from history-based designs where each feature may depend on being related to or dimensioned by predecessor features. Thus changes can be done to the model in seconds instead of hours. *Solid Edge with synchronous technology has a unique geometric solver allowing bi-directional edits, thus eliminating pre-planning of how to make future changes.* This saves time during the initial design because users only need place those parameters and values that are important and allow the rest to be undefined (also called under-constrained). *This is a more natural design methodology. Solid Edge with synchronous technology, thus eliminates virtually all need for regeneration, saving as much as 100X the previous regeneration time and also eliminates the need for feature tree analysis and debugging – an arcane art at best.*

Importing CAD data – the tough becomes simple

In a multi-cad world Solid Edge really shines.

Solid Edge with synchronous technology understands models directly from their geometry. Thus operating in a multi cad environment where typically models are transferred without their history trees becomes easy. *The exciting part is that once foreign data has been read* *into the system, Solid Edge treats it much like an inherent built in model.* With the exception of a few minor limitations, Solid Edge treats the imported model as if it were its own model. Imported models come in as a single body, yet Solid Edge can operate on them to recognize geometry, build geometric relationships, and move and edit directly on the model, as it does to its own data. In fact, we expect that, because of Solid Edge technology, edits to imported data might well be made faster than in the authoring system.

In Solid Edge synchronous technology, the absence of history trees is not a detriment, rather it is a benefit. Not having a history tree leaves one not having to worry about how to edit it and fix failed operations due to a change. Solid Edge synchronous technology allows direct edit tools that are most exciting. For example, you can move and rotate faces, drag and drop holes anywhere, directly change blend radius values, directly change hole diameters, with Live Rules automatically recognizing relationships as it does on intrinsic models built with Solid Edge synchronous technology.

The few known limitations on imported models can readily be modified. Solid Edge does not recognize holes in imported models as hole features; it recognizes them as cylinders. A thin wall is not recognized as a Solid Edge thin wall but is treated as geometric model with independent surfaces. If modifications are needed to these elements, using a variety of different techniques, Solid Edge synchronous technology can easily make changes.

Because Solid Edge has this remarkable capability to auto recognize geometry. and manipulate it, it is much easier to make desired changes. The combination of the selection manager, Live Rules, and the steering wheel allow relatively straightforward manipulation of the model.

In the example of the imported printer model shown below, we were able to recognize the hole feature indicated and were able to move it, with the connecting surfaces automatically and correctly changing to accommodate the new hole location, using only a few mouse clicks. Were one to do this in a traditional modeling system, it would have involved a much more complicated approach, possibly even eliminating many features or completely rebuilding the model. It might easily take 10 times longer to make this change.

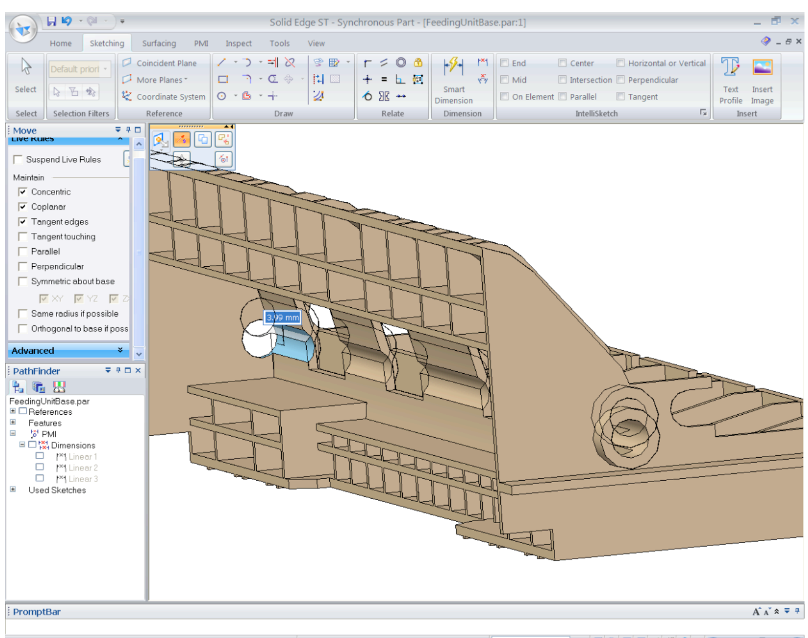

Image 9: Filter cage

Conclusions

Capturing ideas within Solid Edge synchronous technology can result in a faster design process, the result being a completed design in significantly less time than a history-based CAD system. Synchronous technology makes traditional history-based design relationships unnecessary because users have total control of the design process, and thus more design freedom. Not needing such design relationships results in building initial designs faster, and even more important, since most designs are an iterative process, not needing complex history-based relationships makes editing designs easier, resulting in an shorter overall design process.

By itself, beginning the model with a sketch, as is done in most of today's modeling systems doesn't seem that complicated. Yet, Solid Edge with synchronous technology, its region based modeling and its inference logic eliminates many of the rigid user interaction sequences usually required when creating a history-based model that can easily be modified later. In fact, it's possible to create a 3D model with few or no commands.

History-based modeling systems have problems with their ease of use and ability to make edits on existing models. *Even the simplest of changes requires typically a deep understanding of the design procedure or history based approach, so that a design change can be made properly without impacting other objects or elements in the model that were not meant to change.* Frequently in a traditional modeling system, the geometric and dimensional constraints are difficult to see and understand and relate to each other, because they are not in one place, but are buried in a history of how the model was built. Making changes can result in unpredictable results. *Synchronous technology has unbounded editing flexibility by virtue of its flat feature collection allowing bidirectional part solving.*

Benefits

Model creation: Virtually command free creation means less steps in creating a model, yielding a faster design. Adding intent during or after creation using 3D model constraints, 3D driving dimensions, or adding variable equations proves to be easier and more flexible. By not ordering features, but instead collecting them, gives a fast iteration capability, even orders of magnitudes faster than regenerating history-based modeling. By eliminating the engineering time involved in determining how to edit history-based complex models, the result should be less engineering time and not avoiding editing existing models or even rebuilding models. Users should examine their own experiences to judge potential savings in model editing for ECO's or design reuse.

Simplified ease of use: In history-based modeling systems it is necessary to know not only the commands, but the sequence of such commands to complete a workable model. Users are often trained on the myriad of commands. Understanding the required sequences comes only after using the system and explains why experience is so important. Solid Edge synchronous technology greatly simplifies creation and editing because there is no ordered regeneration, Live Rules keeps models in check during un-planned changes, 3D driving dimensions enable intent capture after the fact, procedural features allow parameterized edits without model regeneration, not having feature dependencies allows edits to be made regardless of creation order (for instance, holes can drive faces), and the synchronous, bidirectional solver manages the solution. In addition, the flat command structure provides a simplified interface. Indeed, it might be easier to work in 3D with the Solid Edge's capabilities than trying to edit a 2D drawing to reflect changes.

Working with imported data becomes much easier, since models may be edited directly without regard to how they were built. Most commands work the same for native or imported data, and as such, are CAD neutral. Start from any b-rep model and go on from there. Imagine how powerful this will be when importing models. *Most translation issues will now disappear*.

Are there any drawbacks to synchronous technology? Actually very few. In unconstrained models, sometimes the way a model changes may be unanticipated. For instance, to fit a new dimensional constraint a previously vertical wall may change its angle. This is not necessarily bad, just something to be cognizant of. In my opinion, it's a small price to pay for the added flexibility. Important constraints can easily be added to control model changes more tightly, but are only needed as necessary.

About this paper

This paper summarizes the most important new functions of the Solid Edge with synchronous technology and why they are important for prospective users. Siemens PLM Software sponsored this paper. The impressions and conclusions are those of the author, an independent analyst and consultant in the MCAD industry.

About the author

Raymond Kurland is president of TechniCom Group LLC and its principal consultant and editor. His firm specializes in analyzing MCAD and PLM systems and has been involved in reviewing and comparing such software since 1987. Ray frequently consults with both vendors and users. He can be reached at rayk@technicom.com.

About Siemens PLM Software and the Solid Edge Velocity Series

SOLID EDGE
VELOCITY SERIES
...with Synchronous Technology

Siemens PLM Software, a business unit of the Siemens Industry Automation Division, is a leading global provider of product lifecycle management (PLM) software and services with 5.5 million licensed seats and 51,000 customers worldwide. Solid Edge with Synchronous Technology is a core component of the Velocity Series™ portfolio that eases the growing complexity of product design.

For more information on Siemens PLM Software products and services, visit www.siemens.com/plm .

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