Get the Most out of 2D with Mechanical Structure

An introduction to best practices in 2D design

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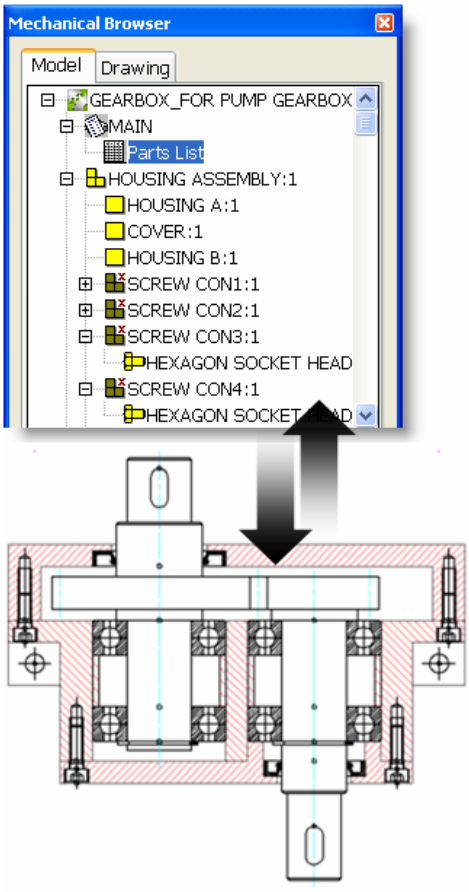
The mechanical structure design tools in AutoCAD® Mechanical software reduce complex and repetitive tasks by streamlining design workflows and providing organizational ease of use. For example, when you look at a gearbox you find parts like screws, housings, cover plates, shafts, gears, and bearings. In the mechanical browser shown below, these parts and their corresponding views can be conveniently grouped into assemblies and subassemblies as they would be in the real world. This helps any designer quickly find and understand all of the important information for any part of the design.

In typical CAD drawings, parts and assemblies are usually represented by many disparate views. There are many ways to organize parts and part views in 2D drawings, such as layers, blocks, or even groups. These different methods are often combined according to complex rules to organize information into parts and assemblies. In the absence of clear guidelines, even designers in the same company may use different methods. As a result, sorting through layers and blocks can get quite confusing, especially when there are changes to the drawing or another designer is trying to understand what has been created. These typical 2D design practices can be difficult to manage, resulting in the following questions:

- Could layers and blocks be easier to use?
- How much effort is required to modify designs?
- Would a more logical method help other designers understand and reuse your designs?

Offering best practices for 2D design, mechanical structure helps you directly draw parts and assemblies instead of working with unorganized lines, arcs, and circles. This is an advantage for anyone who wants to understand or read the drawing, but it is also much easier to make design changes. The examples and concepts presented in the following pages illustrate how mechanical structure saves time, reduces errors, and makes it easier to reuse old drawings for new designs.

A browser provides rich visual information that stores all related views for each part and helps organize drawings.



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1. WHO SHOULD READ THIS PAPER?

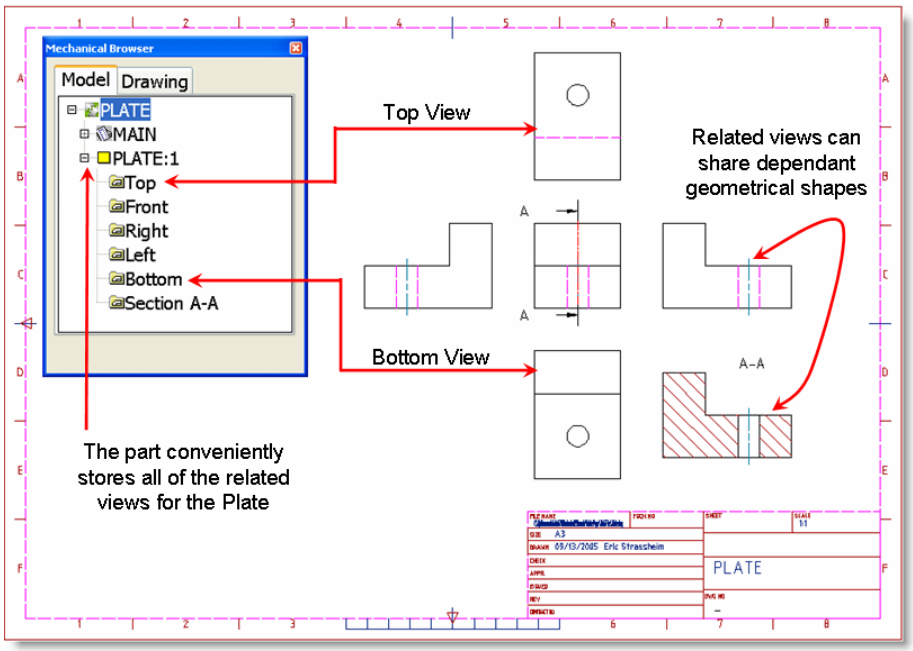
Although this paper is primarily written for AutoCAD® and AutoCAD Mechanical users who currently use blocks and layers/layer groups to organize their 2D drawings, the design practices discussed are applicable to all users of 2D applications.

A full explanation of a new design method called mechanical structure is provided with short examples and some statistics that show how AutoCAD Mechanical users can achieve a **35% reduction in design effort.** For AutoCAD users, the productivity increase would be even greater, but this paper only compares the different methods available in AutoCAD Mechanical for the sake of simplicity. If you are interested in other papers on productivity of AutoCAD Mechanical over AutoCAD, please contact your reseller or visit the product website at www.autodesk.com/autocadmechanical and look for the section labeled “white papers.”

2. HOW DOES MECHANICAL STRUCTURE WORK?

Mechanical structure helps you organize, manage, and reuse parts and assemblies. In this section, a simple example will guide you through the basic tools and concepts that are available with mechanical structure.

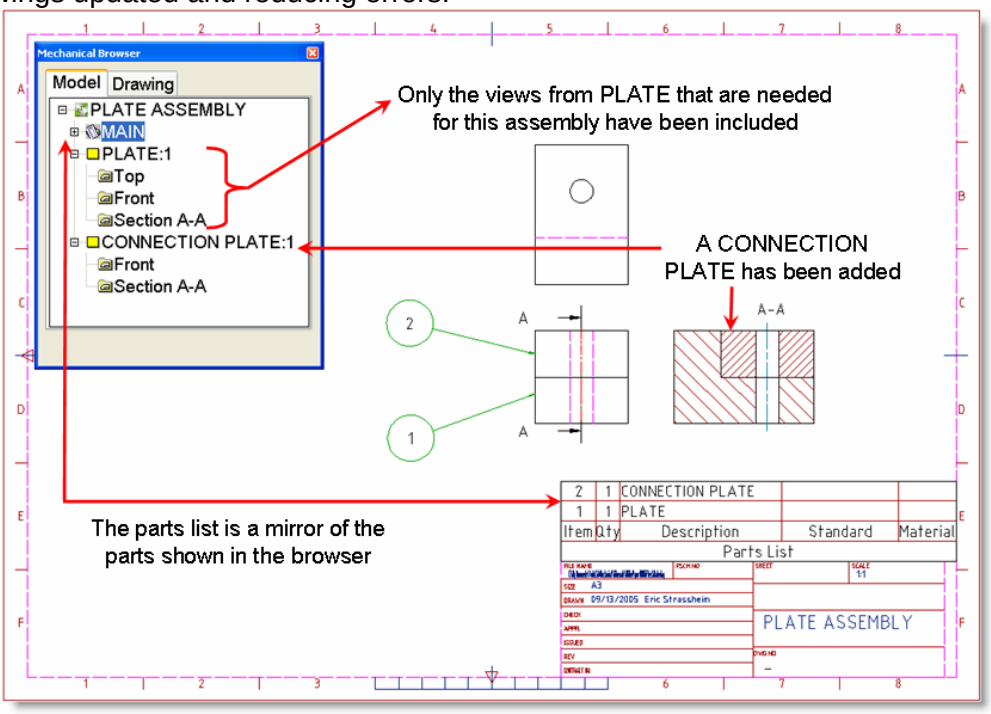
Mechanical structure parts and assemblies are organized in a method similar to how you might store files in folders and sub-folders using Windows® Explorer on a personal computer. The PLATE in the drawing below has six different views that are used to detail this part for manufacturing and to show it placed in assemblies across various drawings. In the browser, parts are clearly labeled with a square icon, and the related views are stored directly under the part. A change made to one view of the part can instantly be reflected in all copies (or instances) of that view in other drawings. Automatically keeping parts and views linked and updated is called associativity, a fundamental concept on which mechanical structure is based.



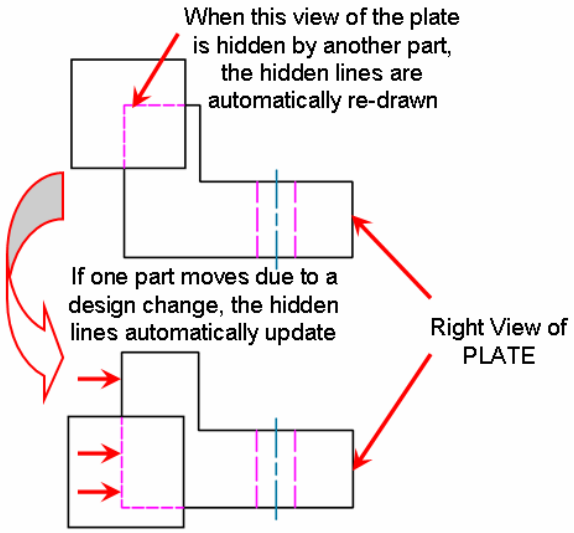
A view can even be associatively linked to another view that is similar. For example, the section A-A view and the right view share the exact same shape. If the outline of the right view changes, the outline of the section view can change accordingly while the hatch remains separate. This helps you store related views that add information like calculations or special details, reducing errors while keeping drawings up-to-date.

The next drawing is a small assembly that includes the PLATE and a new part called the CONNECTION PLATE. In this assembly, only the views from the PLATE that you need for this

drawing are included. For example, the right, left, and bottom view of the PLATE are not used in this drawing and aren't included in the browser. The parts, but not the views, displayed in the browser are used to derive the bill of materials. With the ability to add multiple views to each part, there is enough flexibility to add more information while maintaining an accurate count for the bill of materials. With mechanical structure, the correct bill of materials is naturally refined as the design progresses, keeping drawings updated and reducing errors.

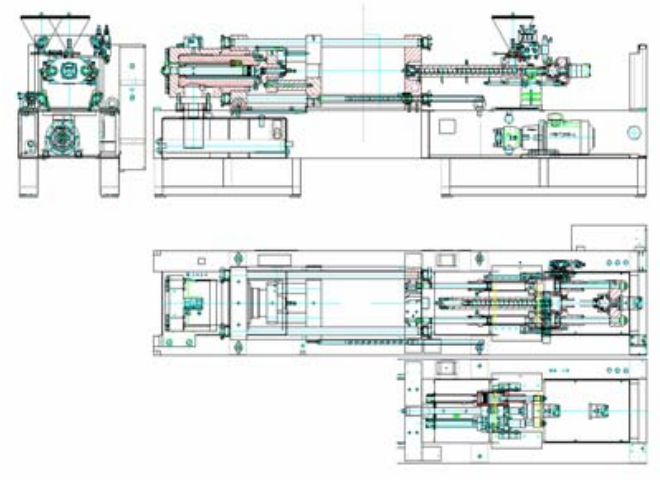


In the next example, consider the situation where a part is partially hidden in an assembly drawing by another part. By simply defining which part is in the foreground and which part is in the background, hidden lines are automatically generated as shown in the picture to the right. If one part changes location, the hidden lines automatically update by healing lines and re-creating geometry. Best of all, hidden lines don't alter the part geometry as it is shown in other drawings or locations! With functionality like this, parts can be reused easily in a variety of situations without causing errors or requiring extensive manual effort to make updates. Keeping the part definition intact is important so that everyone is in agreement on what is being used in the design, from purchasing and inventory to the managers that sign-off on the final design. Accurate part definitions are another basic organizational concept on which mechanical structure was designed.



Mechanical structure is also easy to use. Parts can be structured and nested as necessary to create assemblies by dragging and dropping them within the browser. Changing properties, such as visibility or color, is done with a simple mouse selection from the browser as well. When a team of engineers is working together on a project, AutoCAD Mechanical also provides notifications to each member of the team as designs change. More explanations and examples can be found in the best practices section of this paper.

Customers like Battenfeld, designers of injection molding machines shown below, find value in the solution provided by mechanical structure.

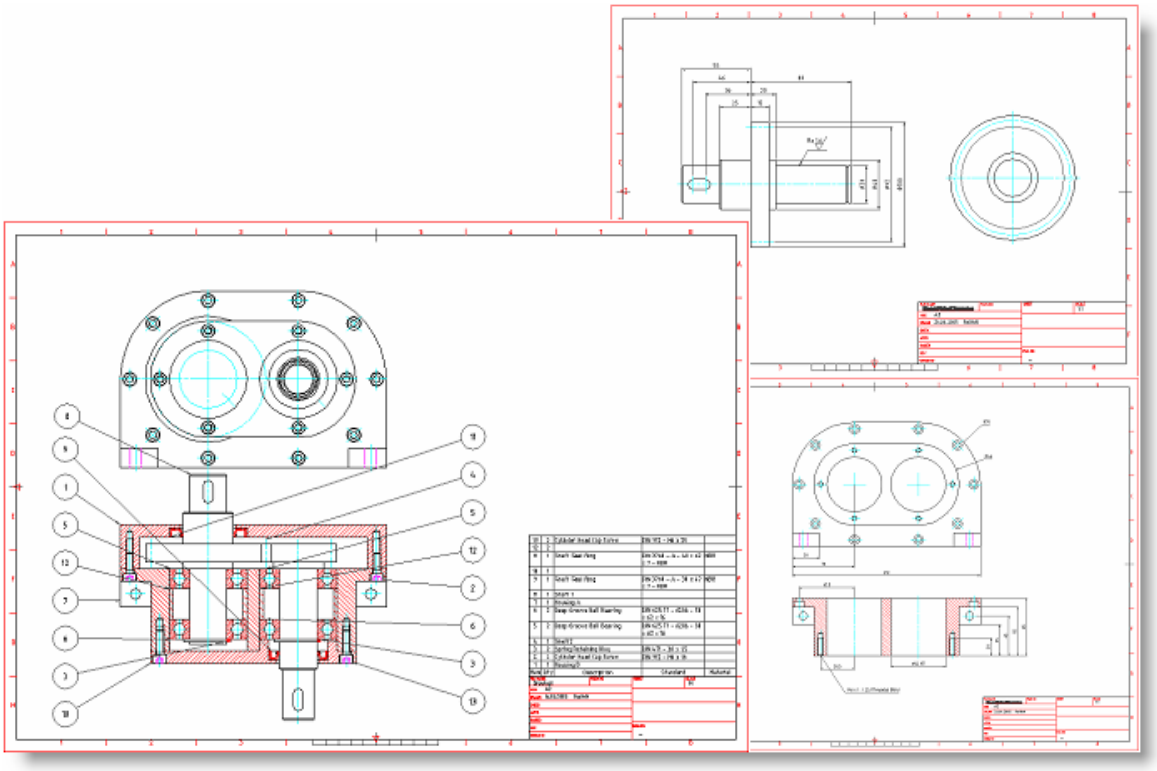


"Designing with a logical part and assembly structure is almost mandatory, because it allows you to group the parts and subassemblies in the same way that you need them later for manufacturing and assembly."

Eduard Schneider
Mechanical Design / PLV
Battenfeld Kunststoffmaschinen Ges.m.b.H

3. A TYPICAL DESIGN COMPARISON*

The gearbox below was designed in AutoCAD Mechanical twice. It was built first with mechanical structure and then designed again with blocks. **In comparing the results, mechanical structure was not only easier and more intuitive, but it reduced the number of keystrokes and mouse clicks by 35%.** If you are an AutoCAD user today, but have not used AutoCAD Mechanical, there is a separate productivity study at www.autodesk.com/autocadmechanical in the "white papers" section that compares AutoCAD with AutoCAD Mechanical.



* Measurements of this productivity analysis are preliminary indicators based on testing over a controlled network. Results are approximate and are subject to error and change. Product information and specifications are subject to change without notice. Autodesk provides this information "as is," without warranty of any kind, either express or implied. While every effort has been made to make the tests as fair and objective as possible, your results may differ.

Creating the gearbox assembly was split into four different tasks: creating or drawing the parts, editing the design in the context of the assembly, detailing the parts in separate drawings, and reusing parts. Each of the different tasks involved in creating the drawings had different characteristics when compared with blocks, and the key findings are discussed in the following sections. Reference the chart below titled "design steps" to read each step of the design as it corresponds to the different tasks.

Creating the design

Most of the time was spent drawing lines and adding details to each specific part, activities that are similar between mechanical structure and blocks. The obvious advantage for mechanical structure was the quick ability to define hidden lines in the front view of the assembly. Additionally, mechanical structure was much easier to use since the browser shows the parent/child relationships while nested relationships of blocks are not always visible and accessible for adding additional information.

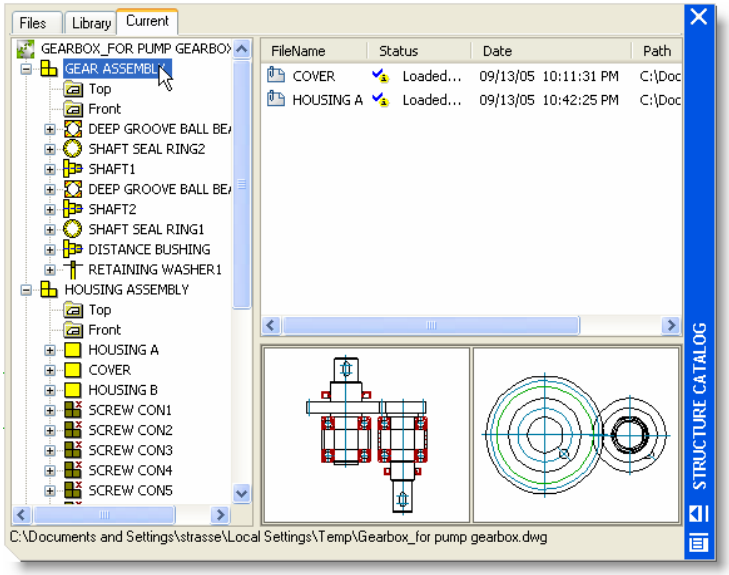
	DESIGN STEPS	TASK
Step 1	Create Shafts, Bearings, and Housing	Create
Step 2	Design Housing and Side Views	Create
Step 3	Structure the Drawing	Create
Step 4	Create Holes in Housing for Shafts	Create
Step 5	Add Screws, Threads, and Holes	Create
Step 6	Create Housing Flange	Create
Step 7	Change Bolts to Counterbore (Clearance)	Edit
Step 8	Modify Shaft to Fit Housing	Edit
Step 9	Insert Seals & Modify Housing	Create
Step 10	Create Cover & Distance Bushings	Create
Step 11	Modify Hidden Lines in Assembly	Create
Step 12	Add Parts List & Balloons	Detail
Step 13	Detail Driver Shaft & Upper Housing	Detail
Step 14	Rename Parts	Edit
Step 15	Externalize Parts for Re-use	Re-Use

Editing the design

Editing the design was nearly 50% faster with mechanical structure, mostly due to the systematic change to the bolts and holes. With blocks, each bolted connection had to be changed individually, while mechanical structure could change an entire bolt pattern with fewer steps. Renaming parts with mechanical structure was also a benefit because hidden line situations with blocks rely on keeping names of blocks involved in hidden lines consistent.

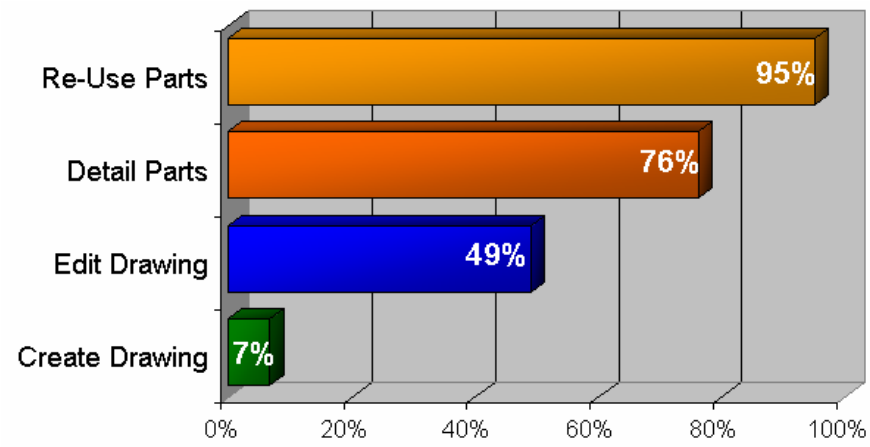
Detailing and reusing the design

Mechanical structure offers efficient ways to reuse parts and assemblies by the use of a structure catalog (shown on the right). The structure catalog helps you search through and choose specific parts and assemblies from another design and insert them directly into your current drawing. Parts used across drawings in mechanical structure maintain associativity, a benefit that reduces effort. For similar parts in the same drawing, both blocks and mechanical structure maintain associativity. Using the hidden line features in mechanical structure is another advantage since a part in the assembly maintained associativity with the detail drawing, despite having different geometrical representations. For example, the part in the assembly may be partially hidden, but the part in the detail drawing is automatically un-hidden. This helped to create the detail drawings with minimal effort.



Conclusions

The chart below shows the percentage savings in mouse clicks and keystrokes when using mechanical structure instead of blocks. As you build libraries and complete more designs, the value of mechanical structure increases because it is 60% more productive for editing and reusing drawings.



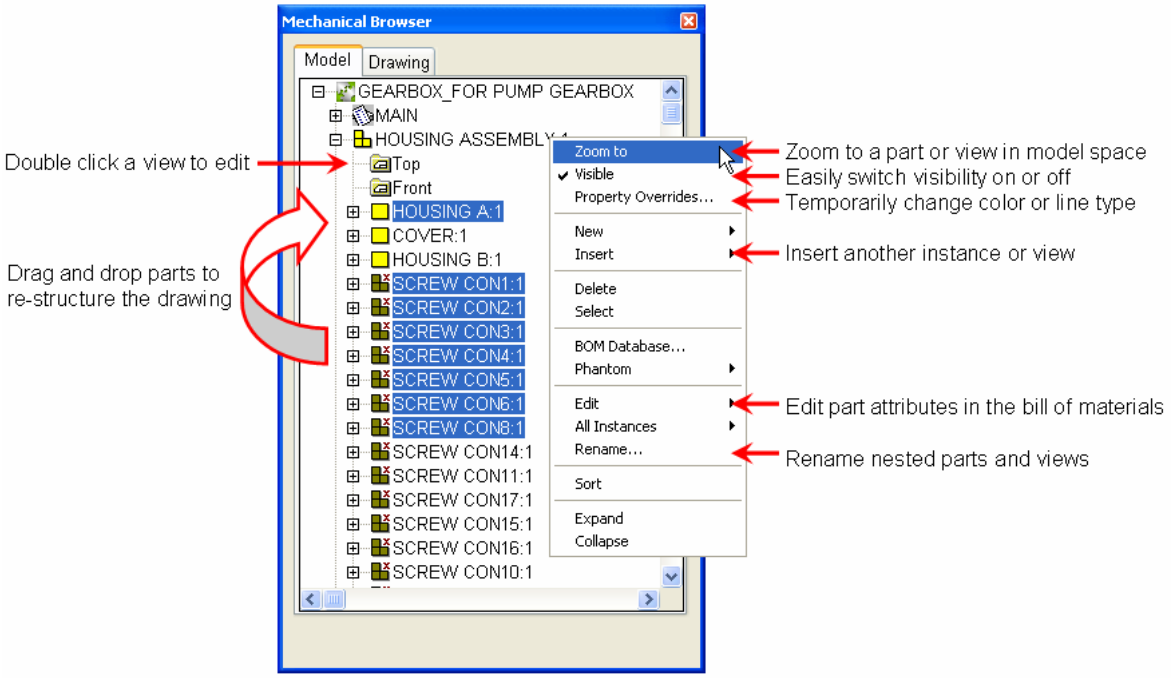
The average savings for all four activities was 35%.

4. BEST PRACTICES FOR 2D DESIGN

Mechanical structure defines productivity for 2D design. The straightforward organizational methods offer streamlined design workflows that reduce complex and repetitive tasks, while the rich visual information displayed during design follows an ease of use philosophy. **Mechanical structure defines the best practices available today for 2D mechanical design.** The following examples explain some of these best practices in more detail.

Clear, organized drawing structures

The part browser shown below is the main interface for creating and managing designs. It provides a highly visual and intelligent graphical user interface with drag-and-drop functionality for structuring, reordering, and organizing design data. Contextual menus allow easy access to edit properties (color, visibility, and part attributes), sort or rename parts, and create or reuse parts and assemblies.



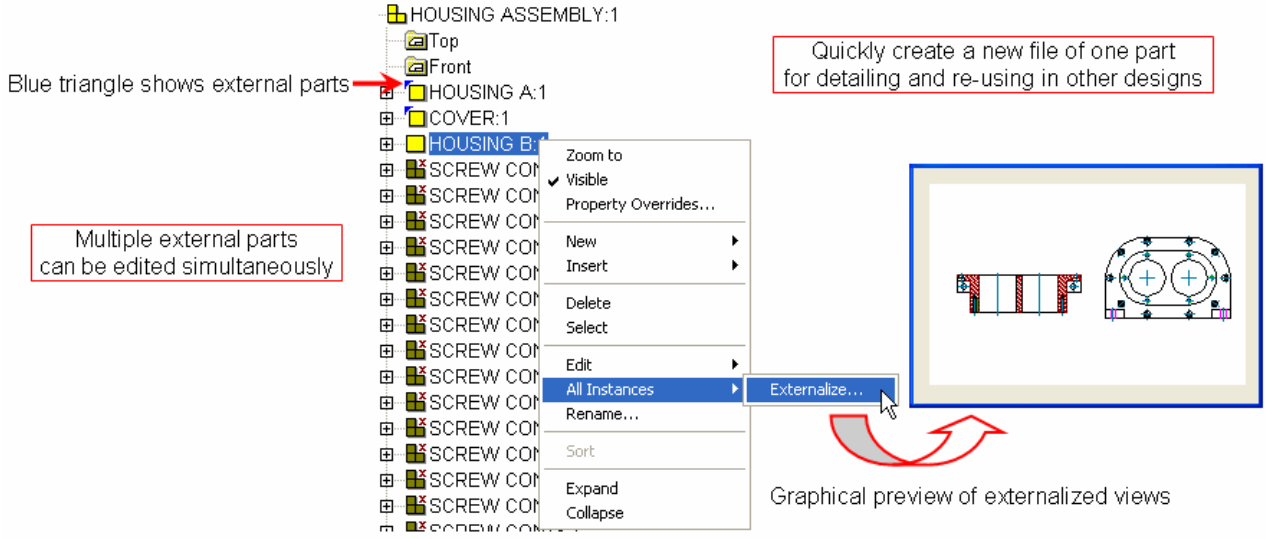
A well-organized bill of materials is a helpful way to see how a design is organized and understand which parts need to be assembled first into subassemblies to produce the final assembly. The browser follows this same organizational logic, where the completed browser is a mirror of the bill of materials. This helps you organize your design, and efficiently reuse a subassembly or part in another design. The browser is a flexible toolset that can fit in with your company design practices and help everyone communicate in a consistent manner. Best of all, the browser helps you be more productive without any additional effort, where making modifications is simple and straightforward.

Re-using parts and assemblies in separate drawings

Many 2D design applications make a local copy of a part that is reused from another drawing. If one of the parts in either drawing changes, the designer must remember where the part in the other drawing is located and make a manual update. This manual workflow is difficult to manage, and can be a consistent cause for design errors.

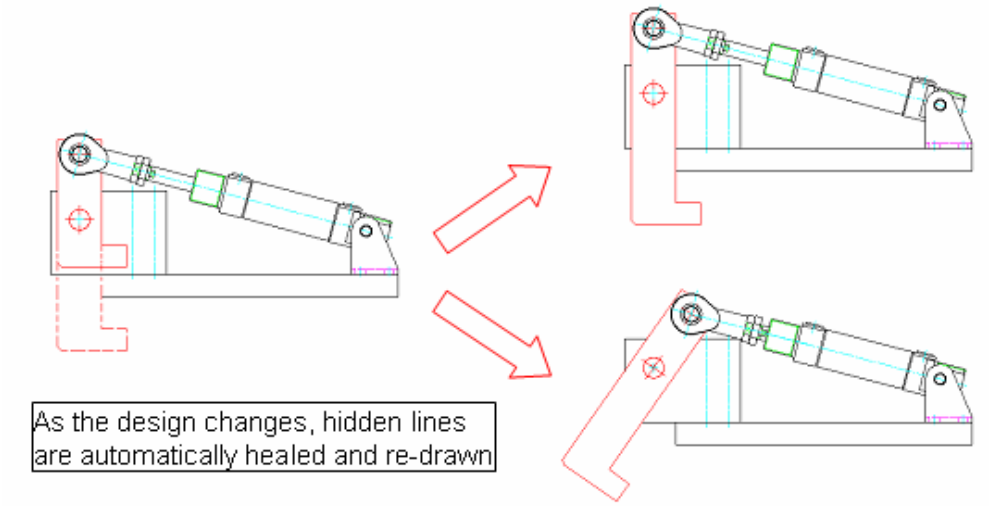
Mechanical structure offers the option to reuse parts and assemblies as either local copies or external references. With external references, a part from another drawing can be added to the current drawing, while maintaining an associative link to the original part. If a designer changes a part design, all other drawings that contain instances of that part are instantly updated to reflect the most current design. This distinct advantage significantly reduces the effort required to make design changes.

Mechanical structure is tightly integrated with external references, including special user interfaces and functionality that streamlines the reuse of parts and assemblies. You can modify several external parts simultaneously, or easily turn a local part into an external part in a separate file. Turning a part from local to external is one short step that is shown in the diagram below with the command called externalize. With mechanical structure, completed drawings become instant libraries available for referenced or copied reuse. Additionally, with external references, several designers can work on the same design at the same time to finish a job more quickly. The external reference workflow is highly productive, helping you share in-process designs, reuse designs, and keep designs up-to-date.



Associative hidden lines

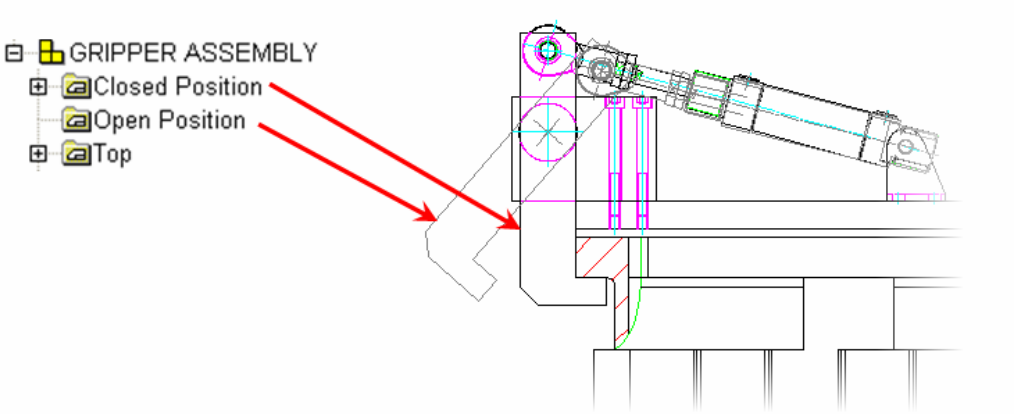
The hidden line functionality offers an efficient way for representing part views in the context of an assembly drawing. It enables you to perform hidden-line calculations based on user-defined foreground and background objects, automatically redrawing geometry and reducing or eliminating the time required to manually re-create views due to iterative changes. The following example shows a closed and open gripper mechanism. As the clamp size changes in the different positions of the design, the parts that are hidden in the background are automatically updated and redrawn!



The real advantage with this functionality is that a part can appear differently in an assembly or detail drawing, while the geometry of the part remains the same. If a design change occurs, all of the different views or instances of the same part will update according to where they are in the design and what level of detail needs to be shown in each view.

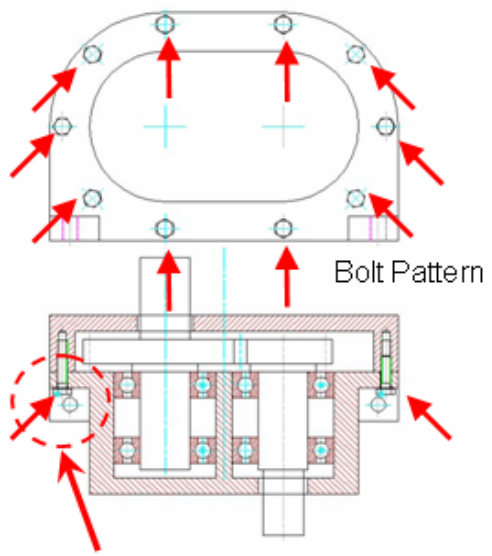
Positional representations

The architecture of separate views being stored under each part or assembly solves a long-standing issue related to showing positional representations in 2D designs. Often the parts shown in an open or closed position (as shown in the drawing below) reuse the exact same parts, but in a different position. Because the alternate position is shown as a view in mechanical structure, it does not add an extra count to the bill of materials, and it can easily have its visibility switched on or off. This helps to simulate possible interferences and design errors, while updates to one part are automatically reflected in all other instances of that part because the views are associative. This clean part and assembly architecture reduces errors and confusion.



Managing standard parts

The bolt pattern shown in the picture to the right is a good example of how mechanical structure can reduce complex and repetitive tasks that are common in 2D design. This bolt pattern was drawn before the mounting flange was added at the base of the design. Now that the design is more complete, interference between the bolts that attach to the flange and the bolts that hold the housing together is easily detected. The designer has chosen to change the ten bolts in the bolt pattern to a counterbored hole to avoid the interference. The selection of the bolt, the threads, and hole size must all be changed in ten different locations. Using mechanical structure, the user can save time by updating all ten representations as a group instead of individually.



Interference between bolts requires a design change

AutoCAD Mechanical contains more than 700,000 standard parts like screws, nuts, washers, pins, rivets, and bushings. It also includes 100,000 pre-drawn standard features like undercuts, keyways, and thread ends. In addition, AutoCAD Mechanical contains more than 8,000 pre-drawn holes such as through holes, blind holes, counter-bored holes, countersunk holes, oblong holes, and others.

5. The 2D DATA MANAGEMENT SOLUTION

The amount of information required to define just one product can be massive. With specific versions for different customers, a diverse set of suppliers, and multiple designers involved, the process of creating products can be pure chaos. With the Autodesk data management solution, all of the design information related to products can be stored, organized, accessed, and leveraged throughout the overall product lifecycle in an efficient way. This helps you manage relationships between all related design data, automate transactions involving the data, and keep everyone updated on the status of any design. The data management solution from Autodesk includes Autodesk® Vault and Autodesk® Productstream™ applications, which are both integrated with AutoCAD Mechanical; AutoCAD® Electrical, Autodesk Inventor® Series, and Autodesk Inventor® Professional.

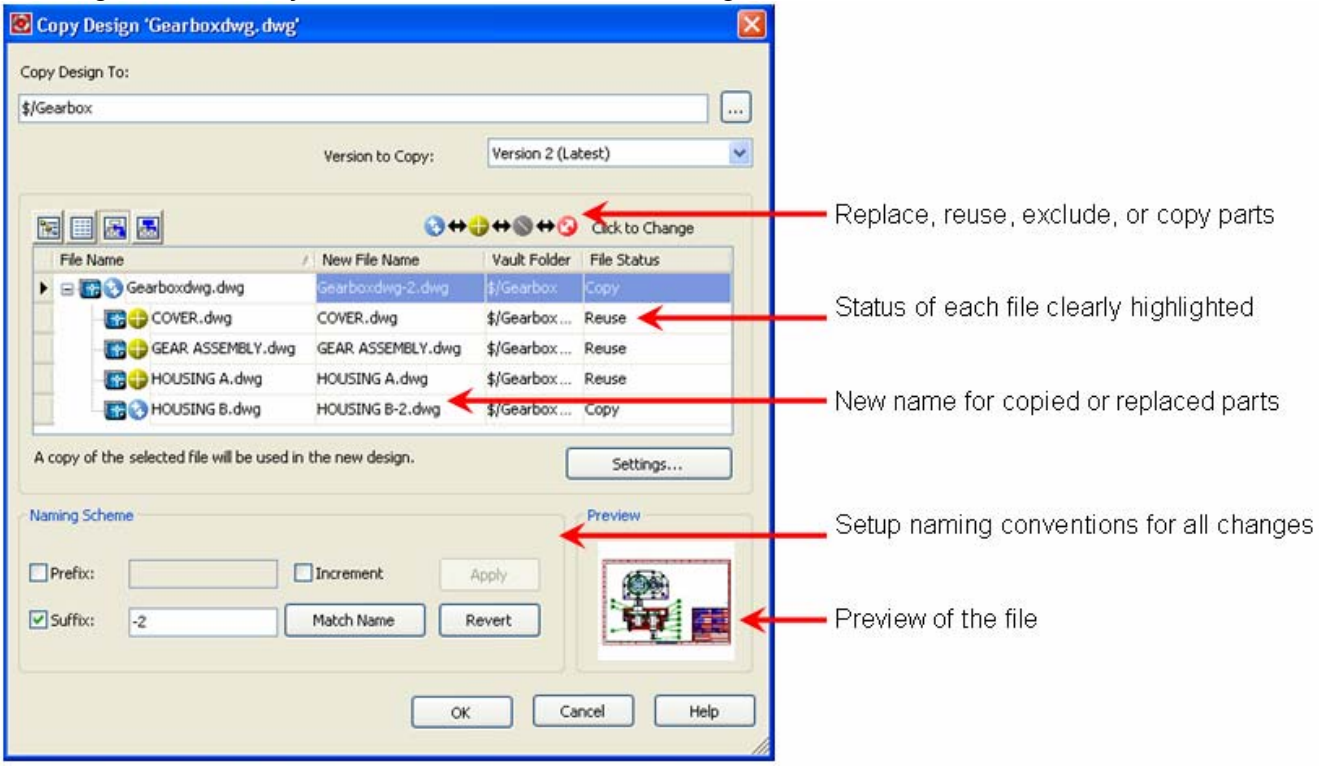
Mechanical structure is a key component of the complete 2D solution for manufacturing offered by Autodesk. Organized data with consistent part definitions are the foundation for reusing designs and sharing related drawing information outside the CAD design department. Inventory systems, production planning, and enterprise resource planning (ERP) tools require detailed and organized information. Mechanical structure is capable of providing this type of information, while also making it easier to design within AutoCAD Mechanical.

For many years, only the largest manufacturers have had the resources to integrate manufacturing and ERP solutions. Because Autodesk's 2D solution is modular and does not require process reengineering, it is a practical solution for the mainstream manufacturer—and one that produces results fast. Autodesk has made powerful data integration affordable for manufacturers of all sizes. Organizations currently using Autodesk design applications already have in place many of the components needed to create a seamless end-to-end solution. The benefits of product lifecycle management (PLM)—out of reach for so many for so long—are now readily available and easily implemented.

Managing 2D work-in-progress

Included with each shipment of AutoCAD Mechanical, the Autodesk Vault application helps engineering securely manage work-in-progress design data and synchronize design-related efforts across teams. The Autodesk Vault automatically indexes drawings along with important information contained in the file that helps you build powerful searches to help find older designs and drawings. Additionally, it stores older versions so that you can easily go back and pick up a previous version if another user over-writes your design. Multiple document types (such as Microsoft® Word and Excel files) can be stored together in one location, keeping the entire design team updated on project status. Separated libraries promote design reuse by managing commonly used parts and assemblies.

Most importantly, Autodesk Vault is integrated into the normal design workflows in AutoCAD Mechanical. For example, Autodesk Vault can tell you how many places each particular part or subassembly is used across all designs. Autodesk Vault provides you with tools to copy and reuse existing design data to reduce the time required to start a new design. A feature called “copy design” (shown below) reduces the steps required to start a new design based on an older design. This intelligent capability saves hours of time by preventing users from having to completely re-create drawings. With Autodesk Vault, you can securely store all versions of design data in a single location so designers can easily find, reference, and reuse the right information.



Automating the release of 2D data to manufacturing

Autodesk Productstream software automates the release management process by managing engineering changes and bills of materials, while enabling the engineering department to maintain control over the design data. It provides confidence that your designs are complete, accurate, approved, and released to manufacturing in a timely and effective manner. With Productstream, designers can leverage organized mechanical structure drawings with planning, purchasing, and sales engineers outside the design department in a consistent fashion.

Sharing 2D data with vendors and customers
The Autodesk Streamline® service extends project visibility outside the four walls of the enterprise, where manufacturing partners and customers can use Autodesk® DWF™ capabilities to view and respond to current versions of the designs online, for better understanding and communication.

AutoCAD Electrical
AutoCAD Electrical is 2D design software created for electrical control designers by electrical control designers. This AutoCAD-based application automates the tedious task of creating ladder drawings. It tracks all wire numbers and component tags, and cross-references coil and contact information for increased drafting productivity. It generates automated reports, such as bills of materials and from-to wire lists, to eliminate virtually all errors associated with manual reports. And it saves time by linking cable and harness information to Autodesk Inventor Professional. AutoCAD Electrical is the only logical choice for an electrical control design application.

Autodesk Inventor
The Autodesk Inventor product line, including both Autodesk Inventor Series and Autodesk Inventor Professional, provides comprehensive and integrated design tools. It combines Autodesk Inventor for 2D / 3D design and documentation, AutoCAD Mechanical for 2D drawing and detailing, Autodesk Vault for data management and specialized tools for creating routed systems and validating designs.

With Autodesk Inventor associatvity functionality in AutoCAD Mechanical, you can access and associatively document 3D parts and assemblies. Just browse through your Autodesk Inventor files and open the 3D part file, and you'll see that a link is automatically created to the AutoCAD Mechanical DWG file. Document and detail the part, and the associative link between the files provides automatic notification of any design changes in the Autodesk Inventor design. And any changes in the Autodesk Inventor file are reflected in the AutoCAD Mechanical file, saving you hours of rework.

Autodesk DWF
Use Autodesk DWF functionality to view, mark up, and print 2D and 3D drawings and models in DWF file format—an emerging standard for sharing data-rich design files electronically. Small, fast, and secure, the DWF format preserves the fidelity and integrity of designs. And all team members can access complex design data without the originating design application.

6. CONCLUSION

Mechanical structure defines the best practices available today for 2D mechanical design. The logical organizational methods streamline design workflows that reduce complex or repetitive tasks, while the rich visual information displayed during design follows an ease of use philosophy that helps you manage design data. Clear organizational tools like the browser are also an advantage for anyone who wants to quickly read or understand a drawing. The direct comparison in this paper showed how you can reduce drawing effort by 35% when you use mechanical structure instead of blocks. For modifying and reusing designs, the savings in mouse clicks and keystrokes improves to 60%. For more information, visit your reseller or the product website for AutoCAD Mechanical at www.autodesk.com/autocadmechanical.

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