SIMULATION AND ANALYSIS

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CAD Product Management

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AGENDA

1. PTC Mathcad

2. Creo Simulate
Creo and PTC Mathcad offer a seamless integration of simulation, analysis and modeling.

- With Creo simulate designers are empowered to easily analyze parts and assemblies, and optimize designs.

- PTC Mathcad combines the ease and familiarity of an engineering notebook with the powerful features of a dedicated engineering calculations application.
AGENDA

1. What is PTC Mathcad?
2. PTC Mathcad Prime 4.0
3. Creo Engineering Notebook
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ENGINEERING CALCULATIONS: TYPICAL ISSUES

- **Inability to capture, share and re-use design intent**
  - Engineering calculations are often created using disparate systems and arcane languages causing poor communication and loss of knowledge.

- **Lack of process and tool standardization**
  - Problems can be introduced due to design intent stored in multiple locations, leading to process inefficiencies and product delays.

- **Lack of early design validation causing need for rework**
  - Is your design optimized? Is it the best trade-off between cost, strength, time-to-market, customer requirements, etc.?

- **Designs not tied to customer requirements**
  - Loss of traceability between market requirements and the final design introduces errors that lead to inefficiencies and delays.

- **Calculation errors lead to poor design decisions and costly rework**
  - Mathematical errors are either caught too late (leading to costly rework) or missed entirely (leading to increased after-market service or costly recalls).
A digital engineering notebook to perform your engineering calculations and manage your design intent.

PTC Mathcad combines the ease and familiarity of an engineering notebook with a powerful mathematical engine.
• Document-oriented approach
  – Multi-document, task-oriented UI
  – WYSIWYG document editing
  – Page/draft (whiteboard) modes
  – Document formatting and control

• Visual presentation features
  – Fully formatted text and images
  – Full control over Math formatting
  – 2D, 3D, polar, and contour plots
  – Collapsible Areas

• Powerful math engine
  – Numeric and Symbolic calculation
  – Rich function library
  – Comprehensive support for units
PTC MATHCAD

- Advanced engineering math tools
  - Programming
  - Solve blocks
  - Custom functions
  - Matrix math capabilities

- Integrations
  - Creo Engineering Notebook
  - Windchill integration
  - Excel component
  - Multiple format file access

- Process enhancements
  - Default and custom templates
  - Legacy worksheet converter
  - Worksheet Include and caching
ENGINEERING CALCULATIONS: USING PTC MATHCAD

- Automatically capture, share and re-use design intent
- Solve complex engineering calculations while documenting automatically in a single tool

- Standardize engineering calculations
- Document and capture key analyses used to determine which, how, and why design decisions were made

- Perform validation and verification throughout design process
- Be assured your design is optimized, with the best trade-off between cost, strength, time-to-market

- Tie the design directly to customer requirements
- Establish traceability between market requirements and the final design, eliminating errors that lead to inefficiencies and delays

- Eliminate calculation errors
- By capturing calculations in natural math notation and automatically managing units it becomes easy to identify and eliminate errors
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1. What is PTC Mathcad?

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Design the next generation of products with PTC Mathcad Prime 4.0 - show, solve, and secure your engineering calculations more effectively than ever.

• Performance Enhancements
  – Document performance improvements

• Content Protection
  – Area protection
  – Area locking

• Interoperability with Third Party Applications
  – Mathcad as an OLE container
  – Copy/Paste multiple regions to Word
  – Save as RTF

• Usability Enhancements
  – Equation wrapping

• Windows 10 support

• Critical bug fixes
• Document Performance Improvements
  – Benefits worksheet-level operations and region-level operations
    • Adding and removing whitespace
    • Separating and moving regions
    • Region selection
    • Text editing
    • Switch to draft mode
    • Pushing regions down
    • Plus additional improvements

<table>
<thead>
<tr>
<th>Main Improvements</th>
<th>Improvement (Worksheet dependent)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Switching between Page/Draft mode</td>
<td>Improved 10 - 30 times</td>
</tr>
<tr>
<td>Orientation - Page Orientation change (Portrait/Landscape)</td>
<td>Improved 10 - 100 times</td>
</tr>
<tr>
<td>Letter - Page size change (change page formats A3, A4, ...)</td>
<td>Improved 10 - 40 times</td>
</tr>
<tr>
<td>Margin - Margin switch between Standard, Narrow and Wide</td>
<td>Improved 10 - 40 times</td>
</tr>
<tr>
<td>Grid Size - Grid size switch between Fine and Standard</td>
<td>Improved 10 - 15 times</td>
</tr>
<tr>
<td>Show Grid</td>
<td>Improved 5 - 10 times</td>
</tr>
<tr>
<td>Add Space</td>
<td>Improved 5 - 10 times</td>
</tr>
<tr>
<td>Remove Space</td>
<td>Improved 5 - 10 times</td>
</tr>
<tr>
<td>Add Page Break</td>
<td>Improved 5 - 10 times</td>
</tr>
<tr>
<td>Separate Regions</td>
<td>Some improvement</td>
</tr>
<tr>
<td>Select All</td>
<td>Improved 10 - 40 times</td>
</tr>
<tr>
<td>Un-Select All</td>
<td>Improved 10 - 40 times</td>
</tr>
<tr>
<td>Math format changes on selected items</td>
<td>Some improvement</td>
</tr>
<tr>
<td>Text format changes on selected items</td>
<td>Some improvement</td>
</tr>
<tr>
<td>Collapse Area</td>
<td>Some improvement</td>
</tr>
</tbody>
</table>

PTC MATHCAD PRIME 4.0: PERFORMANCE ENHANCEMENTS
• Area Protection
  – Protect Area content from edit
  – Password protected or no password
  – Optional timestamp

• Area Locking
  – Lock area display state
    • Open (contents visible), closed (contents hidden) or no lock
Mathcad as an OLE container

- Ability to embed applications as OLE objects within the worksheet
- Any OLE object available on the system
- Can embed new or from file
- Can link to file
• Copy/Paste multiple regions to Word (3rd party apps)
  – User can select multiple regions (contiguous or non-contiguous) and ‘copy’, making them available on the clipboard for paste:
    • Keep Source Formatting – maintain layout from Mathcad
    • Merge Formatting – pastes regions that can be moved as needed

• Save as RTF
  – Save entire worksheet content directly as single RTF file
Equation Wrapping

- Two ways to enter equation break:
  - Editing an equation
    - `ctrl+shift+enter` toggles wrapping on addition, subtraction, multiplication and inline division operators
  - As you type
    - Keyboard shortcuts to insert wrapped addition, subtraction, multiplication and inline division operators

For solid cross section

\[
D_W = \left\{ \begin{array}{ll}
\theta \leq \frac{\pi}{2} & -\frac{R}{6} \cdot \left[ (s \cdot b_1 \cdot (\theta^2 + 3 \cdot r \cdot c + 4 \cdot s \cdot d) + 3 \cdot b_2 \cdot (s \cdot \theta + 2 \cdot r \cdot c^2 - 2 \cdot r \cdot d) - 6 \cdot b_2 \cdot (s - \theta + 2 \cdot c) \right] + \left( \frac{\pi}{2} \right) \cdot \frac{-R}{2} \\
\theta > \frac{\pi}{2} & -\frac{R}{6} \cdot \left[ (s \cdot b_1 \cdot (\theta^2 + 3 \cdot r \cdot c + 4 \cdot s \cdot d) + 3 \cdot b_2 \cdot (s \cdot \theta + 2 \cdot r \cdot c^2 - 2 \cdot r \cdot d) - 6 \cdot b_2 \cdot (s - \theta + 2 \cdot c) \right] + \left( \frac{\pi}{2} \right) \cdot \frac{-R}{2} 
\end{array} \right.
\]
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3. Creo Engineering Notebook
Show Your Work!

Document Design Intent

Analysis Driven Design

Verification and Validation
Document Design Intent

• **Embed** a Mathcad worksheet directly within the Creo model

• Embedded worksheet can be opened, edited and saved within the Creo model

• All design details in the worksheet automatically travel with the Creo model
Analysis Driven Design

• Solve calculations and use the results as dimensions within the Creo model.

• Tag parameters as Outputs in the embedded Mathcad worksheet - values from Mathcad to Creo

• Mathcad output evaluations become available in Creo Parameters Table
Verification and Validation

- Creo parameters further analyzed with Mathcad’s extensive array of math tools.
- Tag parameters as Inputs in the embedded Mathcad worksheet - values from Creo to Mathcad
- Mathcad output definitions become available in Creo Parameters Table
Why Mathcad Prime belongs wherever CAE is used

• Show Your Work!
  – Provide reference/traceability for all loads/numerical input
  – Provide scratchpad for derived inputs
  – Reuse of previous IP for inputs
Show Your Work!

For this brake caliper stress analysis we want to apply a preload to this bolt.

UI requires input of axial force on bolt. **What is this number??**
Show Your Work!

The Bolt axial preload is in fact a complex calculation that can be easily managed in PTC Mathcad.

Solution for Preload Force:

\[ F_p = \left(7.946 \cdot 10^3\right) \text{ N} \]
Show Your Work!

Share the calculated result with Creo

\[ F_p = \frac{d_{\text{mean}} \cdot (\tan \lambda + \mu_s \cdot \sec(\alpha))}{2 \cdot (1 - \mu_s \cdot \tan \lambda \cdot \sec(\alpha))} + \mu_c \cdot \frac{d_{\text{collar}}}{2} \]

Solution for Preload Force:

\[ F_p = (7.946 \times 10^3) \text{ N} \]

Parameter “PRELOAD” now available in Creo:
- Drive geometry in Creo Parametric
- Numerical input to loads, material properties in Creo Simulate
Instead of typing in a number directly, just refer to the parameter we correctly calculated and shared from Mathcad!
Show Your Work!

1. Preload is correctly assigned to bolt.
2. Updates to Mathcad worksheet will be reflected here.
3. Managers can audit/verify that correct calculation is being used.
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1. Usability
2. Process Automation
3. Export
4. Simulation of lattice features
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1. Usability

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3. Export

4. Simulation of lattice features
Overhaul the Analysis and Design Study Experience

- Filtering diagnostic option to show only relevant analysis information
- Dynamic analysis status showing the elapsed time and activity
- Expanding panel to show the analysis run status and convergence plot
Notification support for Creo Simulate

- Indications of changes/issues
- Single access-point to quickly identify common model issues
- Support both Simulate objects and features

Easier way to identify, locate and fix design issues

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Material Enhancements

• More than 110 standard materials within the standard install:
  – Ceramics & Glasses, Composites, Elastomers & Rubbers, Ferrous metals, Foams, Non ferrous metals, plastics and woods

• Material Dialog update to show a dynamic properties panel

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Analysis Node in Model Tree Enhancements

- Access to additional commands via RMB
- Create new analysis via RMB on the Analyses node
- Updated icons representing the status of a given analysis
Synchronize and lock the orientation of a series of results windows to the active window

SYNCHRONIZE ORIENTATION CONTROL

Improved results display
Better selecting methods

- Access to frequently performed actions (Loads/Constraints)
- When selecting geometry, hovering over or RMB on geometry (Surfaces/Edges)
- Customize the Toolbar to your needs

Select on the geometry. Select the geometry and then RMB.
Improved mechanism to adjust models

- Access to Flexible Modeling tools within Creo Simulate
  - Requires an active license of FMX
  - As a Simulation Feature in the model tree
  - Promote FM features to PMA

- New Remove feature to help simplify the analysis model
  - Does not require a license of FMX
Better placing of tolerances

- Relocate tolerance details when in Creo Simulate to avoid overlapping with Simulate Csys
  - Located tolerance to the left of the Csys while in Creo Simulate
  - Move tolerance back to the right corner when in Creo Parametric

GRAPHIC DISPLAY IMPROVEMENTS

Improved graphic display when tolerances are enabled

![Current Display](image1.png)

![Updated Display](image2.png)

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CONTACT INTERFACE IMPROVEMENTS

Allow detection in part mode

- Auto-detect to detect contacts within a component
- New collector for contact auto-detect when in assembly
- Control contact properties from Model Setup

Reduces the need to manually create multiple contacts
Reduce the need to manually fix the poor import geometry

- Auto-detect and create thin solid mesh control options
- Enable mapped mesh control option on solid surfaces in FEM mode
Higher quality results when welds features are present

- Enable auto-detection of weld features in the model
- Support solid welds in Creo Simulate
  - Analyze the new weld feature as solid geometry versus surfaces
  - Support the following types of solid welds: Fillet Welds, Plug/Slot Welds, Butt Welds, Spot Welds.

Automated process for creating solid welds

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Standardized File menu and actions consistent with PMA

- Improved process for saving results to Windchill
  - Publish Creo View file as secondary content for results (*.mrs) and HTML report (*.mrp)
  - Ability to vault information to the workspace unlinked from the stored model directly from Simulate Results

- Improve exchange of information with Creo View

Improve the ability to store and archive results in Windchill
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CREO – DESIGN FOR ADDITIVE MANUFACTURING, CLOSING THE GAP

Design to print workflow

1. CAD Model
2. Model Preparation e.g. define the interior
3. Optimize
4. Then Print
5. Printability Checking e.g. thin walls

Then Slicing

3D Printer

CAD Domain
Users may need up to 4 different types of software to print 3D models.
Goal: To bring the knowledge of Additive Manufacturing capabilities early into the design process.
Lattices for 3D printing
Creo Simulate can drive the lattice definition

• The lattice feature can be analyzed and optimized using Creo simulate

• The lattice feature parameters are exposed to be used along Behavioral Modeling experiments
Lattices analysis and optimization

- Idealized elements
  - Automatic conversion of the lattice into beams, masses and shells.
  - Faster results, lightweight geometry transfer to Creo Simulate
Lattices analysis and optimization

- Fine control over where to apply loads and constraints into the Lattice feature
  - Each beam end-point have a datum point assigned on the open side of the lattice
  - Those datum points can be used to define the load and constraints
Lattices analysis and optimization

- Full geometry
  - Use the meshing capabilities of Creo Simulate
  - More refined model, ideal for the final optimization cycle