Integrated Design and Analysis Applications for Structural Steelwork and Plant Systems

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Where are we?

CAD/CAE Systems provider and Software Developer in Lithuania and Baltic’s since 1996

Software Developer for SolidWorks, 2008
Who we are?

- Since 1997 - SRAC (COSMOS/M) authorized representative in Baltic’s.
- Since 2002 - SolidWorks reseller in Lithuania.
- Since 2004 authorized SolidWorks Corp representative in Lithuania.
- 2005. IN RE staff members achieved Certified SolidWorks Professional and Certified SolidWorks Support Technician status.
- 2005. IN RE signed SolidWorks Research Association Agreement.
- 2006. IN RE staff members achieved Certified COSMOS Support Tech. – Core qualification.
- 2006. IN RE staff members achieved SolidWorks Certified Instructor qualification.
- 2007. IN RE received Authorized Training, Testing & Support Center status.
November 7, 2008; SolidACE, a new company developing computer aided design and engineering tools within the SolidWorks environment for the Architectural, Building and Construction Engineering and Plant Engineering markets, was registered in Lithuania.

SolidACE was created by experienced and dedicated structural steelwork software professionals from IN RE and includes a development team in Dnepropetrovsk, Ukraine, which brings many years of SolidWorks development expertise to the team.


SolidWorks in Structural and Plant Design Systems
Tasks for Plant Design

An Industrial Plant facility is a multi disciplinary design task which includes

- 2D Schematic Model Design
  » P&ID,
  » PFD,
  » Instrumentation,
  » Electrical, etc.

- 3D plant Model Developing (Design & Analysis)
  » Equipment
  » Piping,
  » Structural,
  » Mechanical, etc.

- Operation process design
  » Construction simulation
  » Review
  » Maintenance & Support

Taken from Bentley Systems presentation
Plant components

- **Equipment and Mechanical parts**
  - Tanks, vessels, columns
  - Heat exchangers, boilers
  - Pumps, valves
  - Nozzles, piping components
  - etc.

- **Piping System**
  - Pipes, elbows, tees, reducers
  - Instruments and control systems
  - Supports
  - etc.

- **Steel structures**
  - Building frameworks
  - Pipeline trestles
  - Equipment supports
  - Service, staircases, handrails
  - etc.
SolidWorks tasks in plant design

- **Design of Equipment and Mechanical parts**
  - 3D Modeling
  - Drawings & B.O.M.
  - Stress Analysis
  - Flow & Heat transfer Analysis

- **Design of Piping System**
  - 3D Modeling (Routing)
  - Drawings & B.O.M.
  - Stress & Flow Analysis
  - Data exchange to third party Plant design systems

- **Design of Steel structures**
  - 3D Modeling
  - Drawings & B.O.M.
  - Connection detailing
  - Stress Analysis
SolidWorks for Equipment and Mechanical part design
SolidWorks for Equipment modeling

SolidWorks allows the application of full scale layouts and detailed design of plant equipment and its components:

- Installation units and assemblies
- Production tools and accessories
- Process columns and towers
- Tanks and vessels
- Heat exchangers, boilers
- Piping components
- Pumps, valves, nozzles, fittings,
- Devices and instruments
- Supports and connections
- Mechanical parts and elements
Design Better Products in Pumps

**CENTRIFUGAL PUMPS**
- Armatury
- Czech Republic

**INDUSTRIAL PUMPS**
- Pnevmostroymachina, plc
- Russia

**SOLAR PUMPS**
- Mono - Pumps
- United Kingdom

**VARI PUMP**
- Holmatro
- Netherlands

**PROCESS PUMPS**
- Abs Pumps
- Sweden

**VACUUM PUMPS**
- Telstar
- Spain

**FEED PUMPS**
- HYDAC
- Germany

**API PUMPS**
- Weir Pumps
- United Kingdom

**LOBE PUMPS**
- Waukesha Cherry Burrell
- USA

**CENTRIFUGAL PUMPS**
- Kawamoto Pump
- Japan

**HYDROLIC PUMPS**
- Aerocontrolex Group
- USA

**SCREW PUMPS**
- Kraeuter
- Austria

**SEWAGE PUMPS**
- Monarch Industries
- Canada

**CENTRIFUGAL PUMPS**
- Caprari Spa
- Italy
Design Better Products in Boilers

NUCLEAR POWER
Babcock & Wilcox
USA

DOMESTIC BOILERS
Nefit Fasto Bv
Netherlands

MARINE BOILERS
TPK Nova
Croatia

GAS BOILERS
Aerco
USA

SYSTEM ANALYSIS
Brais Malouin & Associates
Canada

BOILER STOVES
AJ Wells & Sons
United Kingdom

GAS BOILERS
Merloni Termosanitari
Italy

HOT WATER BOILERS
VEA Ab
Sweden

DISTILLER
Cethar Vessels
India

COPPER TUBE BOILERS
A.O. Smith Water Products
USA

STEAM BOILER
Sefako
Poland

SUBCRITICAL STEAM COND
Alstom Power
USA

COMBINATION BOILER
Chaffoteaux & Maury
France

DETAILED DESIGN
Dotec Energo Intl
Czech Republic

DOMESTIC BOILER
Kyungdong Boiler
Korea

PACKAGED TYPE BOILER
Babcock-Hitachi
Philippines
SolidWorks Simulation tools for equipment Analysis

General FEM based Analysis of the equipment and it’s components

- Stress – strain
- Buckling
- Fatigue
- Nonlinear
- Heat transfer

Pressure vessels - code based design

- ASME codes – ‘stress-linearizing’
- Stress combinations of stress results

Flow and Heat transfer Analysis for process
SolidWorks for Piping design
SolidWorks Routing - Piping

Module allows pipeline routing based on specification rules:

- Focus on Systems and small facility design
- Mixture of bends or elbows
- Piping assemblies from Design Library
- Auto-route segments
- Content per DIN, ISO, and ANSI standards
- Easy custom library creation
- Bend table for Manufacturing
- Export pipeline data to PCF format
What is PCF in Plant Design?

PCF – Piping component file:
- Industry standard piping data exchange format;
- Based on ISOGEN standard;
- This is a simple text file;
- Can be represented in 3D using **SmartPlant Isometrics I-View**, including element attributes.

To generate PCF file:
- select ‘Export pipe/tube data’
- PCF file is stored with the SolidWorks assembly file.
PCF file, task #1: Use *I-Run* to generate isometric ISOGEN drawings

PCF file can be converted to:

- a single line different style isometric drawing - spool, weld, pipe-cut, overview, check,
- BOM in text file

Includes dimensions and elevation information

Components replaced by symbols

Extremely lightweight drawing size

The standard for supplying data to pipe spool manufacturing shops

Output file format is DXF – view using e-Drawings and DWGeditor
PCF file, task #2: use *SmartPlant Isometrics* to add additional information and generate ISOGEN drawings.

Using SolidWorks Routing there is no way to add miscellaneous components - supports, spindle directions, heat tracing, bolts, flow arrows, wall/floor symbols and etc. to ISOGEN PCF file.

Possible solutions:

- transfer piping data to SmartPlant Isometrics to add this information to PCF file then …

- generate complete ISOGEN drawing for different pipeline representing style:
  - Spool;
  - Weld;
  - Pipe-cut;
  - Overview, check;
  - Etc.
Using PCF file, task #3: Exchange data with Piping Analysis, Plant Design and Review Software

The PCF file includes all element attributes necessary for Analysis and Review. You can review these attributes in review software.

Using PCF file you can export data to:

- Pipe Stress Analysis Software like *Bentley AutoPIPE*, *CEASER*, and others

- Plant Design and Review Software like *Intergraph PDS*, *SmartPlant Review*, and others
SolidWorks for Steelwork Design
SolidWorks application for steelwork design

Steelwork for Industrial Facilities

- Building frameworks
- Pipelines trestles
- Equipment bearing and supports
- Operating platforms
- Floor girders and grillages
- Roof structures, trusses, lattice girders, ledgers, purlins
- Facades
- Wells, staircases and handrails
SolidWorks tools for Steelwork design

- SolidWorks has embedded tools for the design of welded frame structures (Weldment)
- Weldment features in Part allow the creation of frame elements (beams, columns, trusses) quickly working in the same file.
- At the same time Weldment Parts (frame elements) can be built in big Structural Assemblies (portals, frames, building structures)
- Due to open Weldment libraries, the user can create custom profiles and add necessary properties to existing and new shapes.
- Working with Structural Elements in the Part environment, other SolidWorks modeling tools exist: Move Face, Delete Solid, Move/Copy Bodies, Linear Pattern, …
In working with big structural assemblies, the user needs to know some extra “tips & tricks” to apply them with traditional performance tools and methods “From bolt to bolt connection” modeling technology:

- create each separate part of construction in Part, including all connection details (end plates, stiffeners, etc.):
  - Column with base and header;
  - Truss with connection plates;
  - Beams with end plates and stiffeners

- Don’t create big weldment parts. Max. number of bodies ~30.

- The less bodies in each Part allows for bigger assemblies.
Connection plates in Weldment Parts (tip #2)

a. Create a plate Weldment library like profile library. This will help to:
   • add plate to Weldment parts quickly;
   • calculate plate width/ thickness and length automatically

b. Use end cap and gusset tools
c. Insert plates from “Design Library”
d. Use sketch for plate contour and extrude it

Please note that using b, c, and d methods you will not have plate width/thickness/length calculation automatically.
Steel assemblies usually have a large number of bolted connections. This makes assemblies large and “heavy”.

Several tips on how to make assemblies with bolted connections easier (“lighter”)

- Create bolt/nuts/washer assembly as one part in one body
- Create separately Design Library parts for:
  - Different bolt diameters
  - Fastener Kit (bolt/washers/nuts).
- Control thickness of connection in configuration and Design Table
- Use mate reference to insert fastener kit in assembly
Use Design automation tools inside SolidWorks

- Configuration and Design Tables
- Equations
- DriveWorksXpress

...for quick Design of

- Standard structures
- Generic structures
- Repetitive structures
SolidWorks Simulation for Steelwork Analysis
SolidWorks Simulation for steelwork analysis

- SolidWorks Simulation provides the user with wide and powerful tools for Steelwork FEM based Analysis
- Real Structural elements can be defined using the whole range of Finite Elements: Solid, Shell, Beam. Different types of FE can be combine into one model
- The detailing range depends on physical model geometry level, depth of analysis and expected results and Hardware performance
- Wide range of Specific “clever” FE for Connections to define Contacts and Fixtures to define Joints and Supports
- Using the Pressure Vessel Design Study module separate loadings can be combined by results like Loading Combinations
- Extremely powerful analysis capabilities (Static, Buckling, Nonlinear, Dynamic, Fatigue)
Step #1. Physical Model of Structural Framework
Step #2. Model preparation for Analysis

Several configurations were arranged
- Beam configuration for Framework Analysis
- Four Solid configurations for Connection Analysis

Joint forces (forces at the end of Beams) from the Beam model must be applied for Connection analysis (Solid models) as Remote Loads.
Step #3. Analysis for Beams and Solids

Model name: 2008-Remse-02
Study name: Statics
Plot type: Axial stress (Pa/A) Stress1
Deformation scale: 225.854
Results available:

- Deformed shape
- Deflections and displacements
- Forces (axial and shear forces, bending moments and torsion);
- Stresses;
- “FOS” – factor of safety

No Code Check based Design available!
Step #5. Solid (Shell) results

Results available:

- Deformed shape
- Deflections and displacements
- Stresses;
- Evaluation of Bolt’s capacity
- Contact pressure
- Corner stresses for Weldment lines (depending on generated FE meshing rules)
- “FOS” – factor of safety

No Code Check based Design available!
Review of large plant/structural model
Model review ensure seamless continuity between the engineering design and construction phases of large and complex facilities, required for their optimized operations and life-cycle management.

- Use 3DVia Player and 3DVia Composer for publishing and review of big Structural and Plant Assemblies (models)
- Use 3DVia Composer to create additional documentation, views, animation, visualization of big Structural and Plant Assemblies (models)
Open problems and Future tasks
Integrate SolidWorks with Plant and Structural design applications to fill the gap between Mechanical, Piping and Structural areas.

- Support traditional Plant and Structural exchange formats
  - SDNF,
  - CIS/2
- Support Code Check based Structural Analysis and Design Applications, industry and national market leaders
- Add better support to ISOGEN PCF format
- Support shop machinery NC standard for Steelwork Manufactory
  - DSTV
Integration with Piping Design Systems

- Export pipeline data to AutoPIPE in *.pcf format
- Export Weldment structure data to STAAD.Pro in *.std format
- Joint structural and piping model to integrated code based analysis environment
Integration with Plant and Structural Design Systems

Import structural general arrangement model via SDNF and CIS/2 formats from Intergraph PDS, SmartPlant, AVEVA PDMS, Bentley AutoPlant, Plant Space

Export NC data in DSTV formats

Create shop drawings in SolidWorks

Bi-directional link to structural design software: STAAD.Pro, RAM, Lira, SCAD
Increase SolidWorks productivity for Steelwork design

- Add modeling capabilities for Structural Steel area at the general arrangement stage
- Add modeling capabilities for Structural Steel area at the connection detailing stage
- Support drawing generation conforming to Building and Structural Standards
- Add open interface for Custom Code Application (National Building Design, pressure vessels, etc.) to SolidWorks Simulation

Increase SolidWorks productivity for Piping design

- Read and build solid model from PCF format
- Improve performance to speed up insert operations for bolts, gaskets, welds, etc.
SolidWorks Tasks in Plant and Structural

- Exchange
- Design & Analysis
- Review
- Detailing
- Production
- Drawings
How we envisage steel design tools should look within SolidWorks?
The steel design tool must be:

• A high-performance software application for real-time steel design within the SolidWorks environment, providing tools for 3D solid parametric modelling, analysis and design, connection detailing and automated generation of both drawings and reports.

• Developed to meet the Architectural, Engineering, Construction and Plant (Process & Power) industries requirements for high performance flexible and versatile tools that include extended integration capabilities to Design and Analysis software.

• Capable of maintaining an intelligent and true solid model-based, SolidWorks, architecture that enables the user to create an intelligent, 3D simulated, real-world structure containing all the information required for the design, manufacturing and construction of steelwork structures and assemblies.
Axis based Grid System

- Linear,
- Radial,
- Combined grid system,
- User defined (free) grid system,
- Floor elevation system.

Section and material database. Advanced database of standard steel sections for International standards.

Material database for structural steel linked to sections.
3D Modelling features

Advanced possibilities to create and place structural members like Weldment and Structural Members both in Part and Assembly

- by nodes
- by selected sketch segments
- as single members
- in groups
- in arrays

Advanced possibilities of member editing and positioning –

- rotating
- mirroring
- offsetting.
Advanced possibilities for member alignment - by construction line, one item at a time.

Special features for setting up rules and priorities for connection cutting.

Cutting by intersection shape by selected hierarchy with shortening and gaps.
Generation and placing of connection plates like end plates, stiffening plates and additional connection plates.

Extended fastener database (bolts, nuts, washers) and intelligent embedded tools for placing and adjustment of fasteners.


Solutions for connection copy within the model from other models.
Export of SolidWorks models to third party structural analysis and code based design software from Part or Assembly Weldment and Structural elements as:

- sketch lines
- structural objects

Import of an analysis model from structural analysis software to SolidWorks by

- sketch points, sketch lines,
- Sections with sections orientation,
- materials

Managing of Weldment or Structural members by the rules for assembly files, Part files and multi-body files.

Updating model by design results
Generation of standard structural drawings

- general arrangement construction drawings
- detailed fabrication drawings
- connection detailing drawings
- workshop drawings

Generation of Axis Grid representation object - axis lines, axis balloons and names, ground level line. Automatic dimensioning between grid axis, and between general grid lines.

Detailed and general material lists and reports.
Export/Import of SDNF (Steel Detailing Neutral File).

- Import of SDNF data file to SolidWorks part or assembly.
- Export of SolidWorks part or assembly model to SDNF format.
Thank you

Q & A

P.S. Meet SolidACE representatives at Stand 111 in the Partner Pavilion to learn more and to discuss SolidWorks Applications for the Plant and Structural market.