**Summary**

I-deas NX Series Master Surfacing augments Master Modeler with an extended set of three-dimensional solid modeling tools for complex geometry creation, while still using parametric and dimension-driven design intent. Master Surfacing provides tools for defining and modifying complex, sculpted surfaces that can be portions of either solid parts or open surface parts. Surface creation tools included in Master Surfacing offer the same robust capabilities for capturing design intent, and therefore modification and replay, as found in Master Modeler.

**Features**

- Design intent-driven surfacing tools including loft, sweep, variational sweep, emboss, flange, and surface-by-boundary
- Industry-unique Variational Sweep capability which allows cross sections to vary along path and intersecting geometry based on varying constraint network
- Surface offset, trim, extend, and unwrap capabilities
- Complex curve creation tools for three-dimensional splines
- Freeform shaping tools for geometry that is not intended to be dimension-driven
- Surface analysis tools

Master Surfacing provides lofting, sweeping, and blending capabilities which allow associative feature-based definition of extremely complex geometry. Color contour displays help you clearly interpret surface curvature.

Master Surfacing

Master Surfacing is the advanced surface modeling complement to Master Modeler. It helps you quickly and easily design and iteratively modify complex sculptured surface parts. Master Surfacing provides a rich set of curve and surface creation tools for lofting, sweeping, and blending surfaces, giving you excellent local and overall control of surface shape. Not only can you create your shape, but you can also easily make design changes because relationships between geometry entities such as surface tangencies are maintained throughout the design effort. Advanced fairing operations help you remove bulges and achieve excellent local shape control of freeform surfaces. As a result, changes can be rapidly examined without the need to regenerate each individual surface. The result is a smooth, attractive, highly engineered, and manufacturable surface that enhances the design of your product.

**Modeling foundation**

I-deas NX Series is NURBS (non-uniform rational B-splines) based. NURBS geometry allows you to accurately model analytical, highly sculptured surfaces without approximation, using a single basic set of commands. The result is a set of surfaces or a topologically complete trimmed surface solid model. The model can participate in all geometric modeling operations, interference checks, mass properties calculations, hidden line removal, and shaded image creation. Major features include:

- Fully integrated surface and solid modeling
Benefits
Create and modify the most complex geometric shapes in an intuitive and comprehensive environment
Enable mixed environment of design-intent and dimension-driven shapes with unconstrained, free form shapes
Fully integrated with feature driven part history introduced in Master Modeler
Easily modify and update complex shapes which require manual re-creation in other systems

• Double precision NURBS modeling represents arcs, conics, and high-degree Bezier curves without approximation
• Unlimited control points per entity
• Completely integrated unified wireframe, surfaces, trimmed surfaces, and solid data structure

Modeling complex surfaces
Once you master a small set of curve and surface modeling commands, the power of an advanced surface modeler is available to you. Master Surfacing includes a full set of construction tools for creating and manipulating curves and surfaces. These tools provide exceptional local and overall control of curves and surfaces.

The following are some key capabilities:

Curve operations
• Accurate fitting of unevenly spaced points
• Conic curves
• Tangency, curvature, and inflection control
• Extract curves from surface intersections and edges of parts
• Extract curves from surface ISO parametric lines
• Project onto a surface
• Curves created through a series of surface points
• Offset curves, associative
• Stretch, join, or match curves

Surface operations – creation and modification
• Planar and ruled surfaces
• Surfaces of revolution

Design tools in Master Surfacing can be used to create both open surface and closed solid parts, in close conjunction modeling tools provided in Master Modeler, resulting in dimension-driven products that incorporate complex surfaces.
• Lofting:
  • Use a minimum of one cross section and two rails, or two rails to define the surface
  • Use just cross sections or cross sections and rails to control surface shape in two directions
  • Control surface tangency at each defining section
  • Optional control of mapping between cross sections with differing numbers of curves
• Sweeping:
  • Path controls the shape of the surface in one direction
  • Minimum of one path curve and one cross section needed to model surface
  • Surface is automatically interpolated between shapes of cross sections
  • Cross section curves for sweeping and lofting may be open and non-planar
  • Various methods for controlling orientation of cross sections
• Mesh of curves:
  • Create sections in two directions
  • Single surface is created
• Emboss:
  • Can be used to create an embossed surface feature on an open or closed part
  • Material can be added on either side of the base surfaces, or through the surfaces
  • Can also create joggles, which are emboss features whose edges are trimmed by adjacent faces or by a user-selectable vector (if the emboss falls on a free-edge boundary)
• Variational surface feature:
  • Can create freeform, history-based features that are independent or dependant of the surfaces upon which they are created
• Match edges:
  • Match a number of tangent continuous surfaces along a series of edges to another set of tangent continuous surfaces
• Overcrown:
  • Used to add curvature to a thin part to compensate for springback when the part is stamped in a die
  • Not actually a feature of the part design, but is used to compensate for the manufacturing process
• Imageware freeform feature:
  • The best method of integrating an Imageware model into the I-deas modeling and TDM environment
  • Models can be scan data, reverse engineered surfaces, high quality surfaces, modified I-deas surfaces, etc.

• Offset surface:
  • Similar to shelling a part, but for individual surfaces
  • Can choose to keep both the selected geometry and the new offset surface (default), or keep only the offset surface

• Material side:
  • Used to specify the material side of a cutting surface on a part or assembly instance
  • When you cut a solid with a surface, the part of the solid on the material side of the surface is discarded

• Extend surfaces:
  • Used to extend a surface or set of surfaces
  • Can specify a fixed distance for the extension, or you can pick a plane or surface to extend to
  • Can also extend two surfaces to make a corner between them

• Flange:
  • Creates a constant sized single surface flange along the selected edges with a constant angle to the defining surfaces

• Unwrap surface:
  • Used to unwrap cylindrical, conical, and tabulated cylinder surfaces

• Points: Highly sculptured surfaces can be created from point data imported from 3D digitization, or from special purpose analysis/design tools
  • Ordered mesh of points
  • Random cloud of points

• Use existing surfaces and solid edges as defining curves when creating surfaces. New surfaces are automatically stitched an associative to these edges

• Automatic mid-surface generation: A generalized approach, independent of feature creation, extracts mid-surface geometry or use in shell meshing of molded and cast parts

• Fully automatic mid-surface generation for most parts, plus additional interactive tools

• Automatic surface extension and trimming and in-surface feature suppression are available

• Shell element thickness is automatically derived from solid part geometry using an icon
• Tangency control:
  • Control tangency at surface boundaries either by using an existing edge or surface, or by defining tangent vectors at surface end boundaries
  • Tangency weighting
• Trim, extend, merge, and stitch/unstitch surfaces
• Surfaces imported from other CAD systems can be sewn-up into solids and used to trim other surfaces or solids
• Split and merge surface edges
• Non-manifold geometry abstraction tools for such operations as creating internal partitions within the part model
• Dynamic curve and surface manipulation:
  • Modify surfaces by dragging points in 3D space
  • Position modification effects within a zone
  • Apply magnets and other tools to control shape

Variational Sweep
Variational Sweep takes the “sketch-in-place” concept for planar geometry, and extends it to complex freeform geometry.

Variational Sweep lets you sketch a variational section “in place” that will follow multiple rails (curves or surface edges), positionally and with surface edge tangency. The implementation allows you to create, with a few familiar commands, surfaces that in other systems take an order of magnitude more difficult user interactions to develop.
Sample situations that can be addressed with Variational Sweep are:

- multi-rail sweep
- variable radius blends with sliding/ tangent edges
- true dimension-driven freeform surfaces
- modeling of draft on freeform surfaces

**Ease of design change and shape control**
Master Surfacing uses a variational constraint-based approach to surface and solid modeling. This technology lets you easily capture design intent, thereby allowing design changes to be made rapidly with unparalleled associativity.

Surfaces are associated to underlying curves and part edges. When a part design changes, surfaces associated to the part change with it automatically. The variational capabilities of Master Surfacing also allow you to create equational relationships between surface control variables to control surface shape.

In addition, for free form surfaces that are not easily defined by dimensions and equations, Master Surfacing provides industry-unique variational shaping tools which allow you to achieve your desired surface shape. These methods use energy-minimization techniques to shape underlying surface curves using advanced high-level operations such as pushing, twisting, repelling, and attracting to intuitively shape geometry. You can achieve fairness of the resulting shape by interacting directly with the real geometry — not with control points, weights, and knots as in traditional surface modeling systems. The following important capabilities enhance your ability to control and reshape surfaces to achieve difficult styling or engineering objectives:

- Surfaces are associative to defining curve/part edges and update with changes to the parent solid
- Variational shape control via modification of dimensional or geometric constraints
- Tangency associativity: surfaces constrained to be tangent remain so after design changes
- Surfaces can be controlled by equations
- Advanced energy-based curve smoothing and shaping tools act directly on real geometry instead of intermediate control points
- Achieve slowly varying curvature properties and eliminate undesirable local bulges (fairness) which can detract from the aesthetic, machining, or aerodynamic properties of your surface
- High-order end/edge control including exact fixed boundary conditions
- High-order exact tangency and curvature, continuity control at curve/surface junctures
- Intentionally introduce local bulges or inflections on curves while maintaining global smoothness
• Shape curves locally to fit specific point geometry or to follow the shape of existing geometry
• Rigidity control allows the shaping of a portion of the geometry while keeping the remainder fixed
• Indirect shaping tools allow most of the geometry to achieve flatness or cylindricity while also maintaining given end conditions
• Continuous intensity controls to define relative strength with which geometry resists such operations as flattening or stretching
• Direct real-time user interaction which drives the shaping process and provides direct visual feedback
• Connector constraints join curves into curve networks. Moving a connector moves all attached curves

Visualization and analysis
With surfaces and solids created in Master Surfacing, you can use all I-deas visualization tools including shaded images, hidden line processing, perspective views, and evaluated surface displays. In addition, to help you evaluate curves and surfaces, specific display capabilities and evaluation tools are available including:
• Curvature analysis via color contour display or Isolines of Gaussian, mean, or principal curvature
• Surface normal/tangency display vector normal to or tangent to surface or curve
• List curvature and normal values of surface at a point
• Check surface/surface boundaries

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