Rotational Molding Design Case Studies

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Case Study #1 – Car Wash Kiosk

In the Beginning

Initial Meeting:

- Highlight major design objectives
- Review possible product configurations
- Define major product requirements
- Review schedule
- Investment & cost
- Discuss marketing objectives

Current Products – vacuum formed & sheet metal construction

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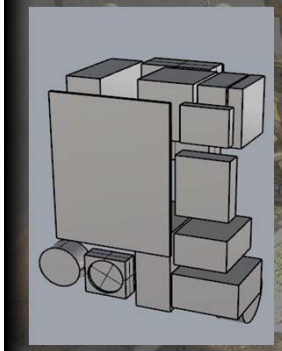
General Specifications



General Specifications

- The new module should be easy to assemble
- The structure and covers cover must be aesthetically appealing, setting a new look for the next 10+ years
- The new structure will support a number of components arranged in the image shown.
- The new modules must be easy to service
- The new modules must be easy to assemble and test during production
- New modules must be water resistant from rain
- New modules must comply with security requirements
- New modules must be very reliable and long lasting.
- Kiosk must withstand environmental conditions from Arizona to Alaska

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Site Visits

Site visits revealed important design considerations including:

- Chemical resistance
- User interface
- Ergonomics
- Impact requirements
- Installation requirements
- Product branding & image
- Servicing requirements
- Security & vandalism

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Site Visits

Site visits provided our design team with invaluable information about product branding, the environment, user interface, and basic product configuration.

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Internal Components

All internal components were identified and modeled in CAD

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Initial Concepts

- Initial concepts focused on identifying an image for the product
- Specific manufacturing processes were not considered at this stage of development

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Final Selected Concept

What processes will most cost effectively satisfy all the product requirements?

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Early Engineering Details

Thermoformed covers sandwiching rotationally molded center piece

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Advantages of a Rotationally Molded Center Part

- Most cost effective option of any process
- One piece – no sub-assembly labor
- One piece – no tolerance problems
- One piece – Very structural
- One piece – Water tight
- One piece – Easy assembly & installation
- One piece - Lowest tooling investment

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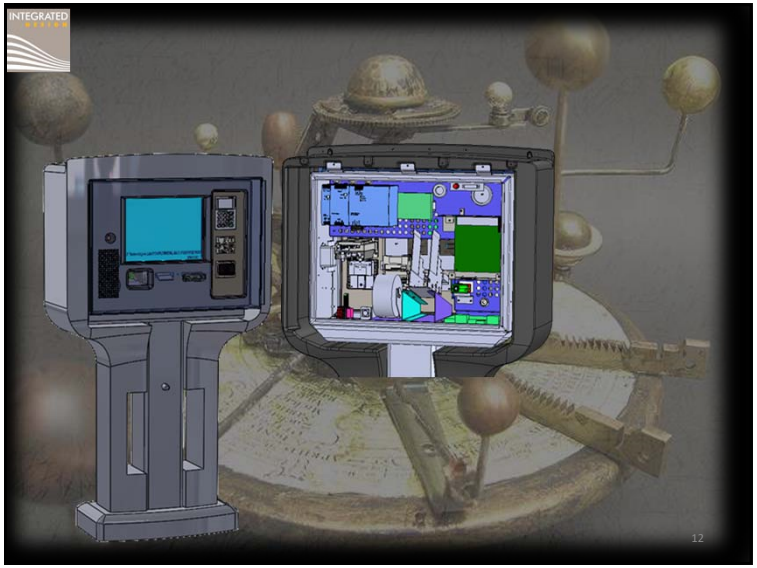

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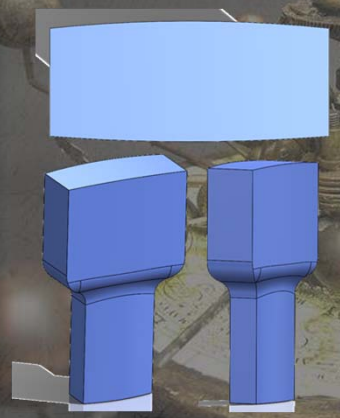
Initial Model



Initial CAD Model : Designed with flat sides and curved front an rear surfaces

- Easy to mold with simple flat parting line
- No draft required
- Easy to design
- Lowest cost tool

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Flat Sides

Big Concern-

Warpage along cosmetic faces (exaggerated)

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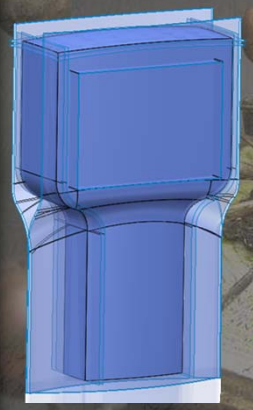
Added Design Complexity



All exterior surfaces are complex swept compound curved surfaces to minimize chances or warpage

- All flat surfaces designed with compound curved surfaces to minimize warpage
- Added complexity to CAD model, tool and additional cost but assured production consistency

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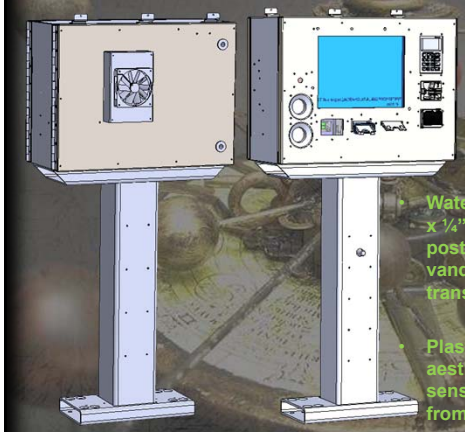
Internal Structure



- Water proof steel cabinet and 8" x ¼" thick steel tubular base post provides a secure and vandal proof structure for transaction devices.
- Plastic covers provide an aesthetic exterior which insulate sensitive internal electronics from temperature extremes.

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Final Production CAD Design

Single rotationally molded part drastically reduced complexity, cost and potential production problems.

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Final Production Rotationally Molded Core

Multi-functional center core was designed to perform many functions. The only process for producing this complex shape and comply with all the critical performance specifications is rotational molding.

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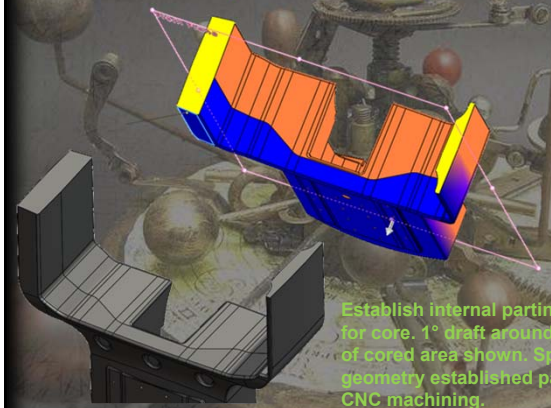
In Depth Design Review



Establish internal parting lines and draft for core. 1° draft around all internal walls of cored area shown. Split lines in geometry established parting lines for CNC machining.

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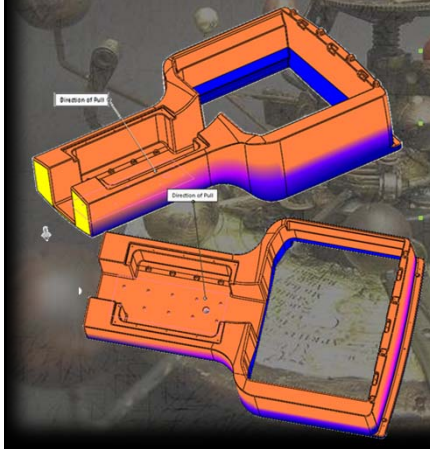
Draft Analysis



- All surfaces were modified to include appropriate draft as shown in the images
- Bottom (yellow) surface did not require draft and was required to be molded flat since it was a mounting surface.
- Curved side walls formed undercuts as shown in the images. These sides were molded with slides.

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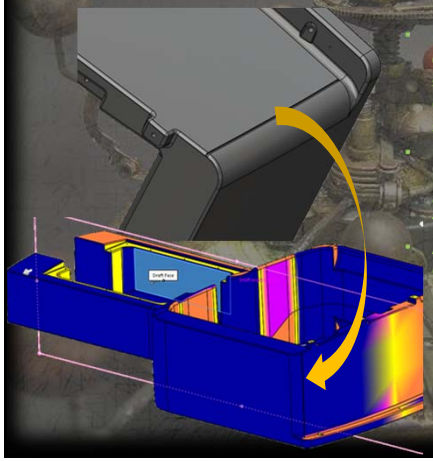
Draft Analysis



- Parting lines details were established for slides on either side. Intentional crevice was designed to hide witness line of slide.
- Discussions of entire parting line between slides and main tool all around part were reviewed with tool maker and molder.
- All these design features were captured in the CAD files

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Rotational Mold & Fixture

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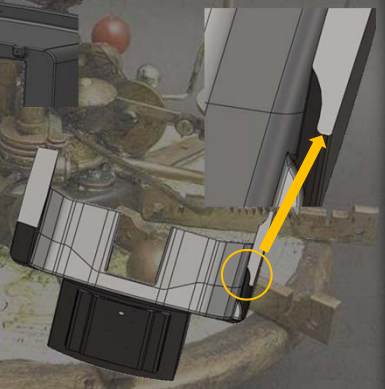
Potential Bridging

Restrictions based on aesthetics, function and overall size limitations resulted in numerous design challenges which could result in:

- Bridging
- Partial fills
- Pinholes

Discussions with molder confirmed part geometry would minimize any bridging or partial fills

Since front face was covered by thermoformed plastic covers, small pin holes would be acceptable.



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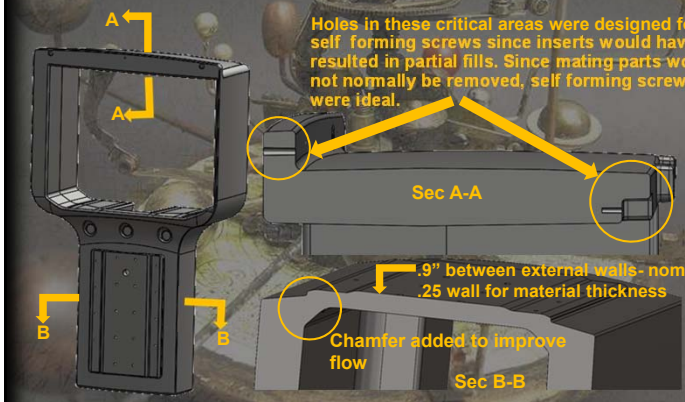
Bridging Areas of Concern



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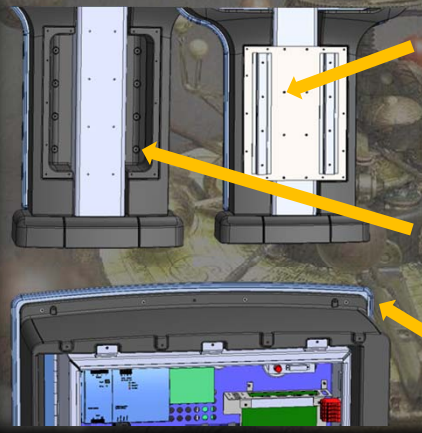
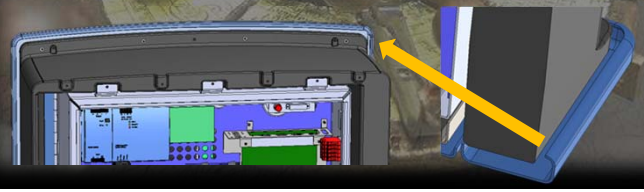
Tolerances



Tolerance studies and discussions with molder in all critical areas

Affects:

- Order placements for mating parts
- Design
- Clearances
- Ease of assembly
- Quality



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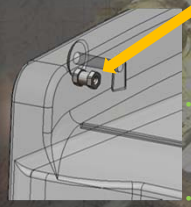
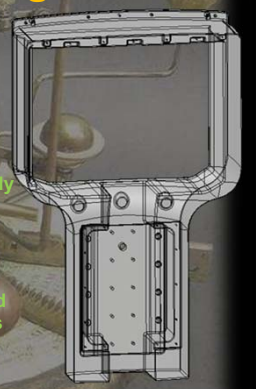
Inserts vs. Self Forming Screws





- Inserts were restricted to only those areas where screws would be required to be removed and assembled multiple times.
- Only 4 inserts were specified minimizing production costs and potential problems with bridging in tight areas.
- Remainder of holes were molded in with core pins

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Bulk Density Calculations

- Total enclosed mold volume (V_{et})
- Total part volume @ specified wall (V_{pt})
- Material density (ρ_m)
- Material bulk density (ρ_b) (typically $3x\rho_m$)
  - $\rho_m \times V_{pt} = P_{wt}$
  - $P_{wt}/\rho_b = V_{bulk}$

V_{bulk} must be < V_{et}

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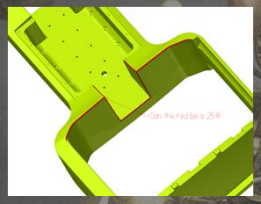
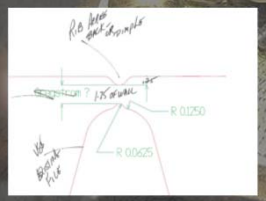
Review Design with Tool Maker & Molder





- Collaboration with tool maker and molder is essential during the design development
- Add radii and optimize kiss-off details for optimum processing requirements

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First Article Inspection

- Rotationally molded main body and assembly with pressure formed covers
- Client did not accept uneven gap around hinged door.
- Clearance between door and front panel was 1/8" all around
- Gap at top was ¼" vs. bottom which was virtually line to line

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Puzzling Misalignments

- Rear mounting holes did not align to inner steel structure.
- Alignment varied from one molded part to the next
- Overall height of rotationally molded parts were within specs
- Contradiction between measurements and observed fits between parts
- Pressure formed parts were flat and within specifications

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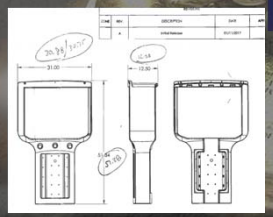
Comprehensive First Article Analysis



In depth analysis of total assembly was performed to pinpoint the source of problem

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First Production Inspection

- Analysis of rotationally molded part revealed a slight cupping which raised the rear top walls and dropped the front edge causing causing the misalignment
- CAD image shows this condition in an exaggerated
- deformation

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Debugging Methodology

- Correction of cupping solved the problem – No tooling changes were required after source of problem was identified
- Advice- ALWAYS find the root cause of problems before making any hasty tooling modifications

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Final Production Units

Final production units were a huge success at the annual car wash conference held in Las Vegas

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Modular Playground Slide

Retail modular spiral slide available in 5,6,7, & 9 foot heights

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The Amish Story

- Family & community
- Faith & Vision
- Business savvy
- Courage
- Determination
- Brains

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King Swing




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The Original Slide


Original slide was rotationally molded as enclosed sectional tubes which could be configured as right or left hand spirals and straight sections

Problems:

- Aesthetics- Industrial look
- Safety – Parents cannot see children
- High cost – Purchased as
- Installation - Difficult

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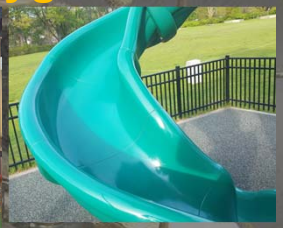
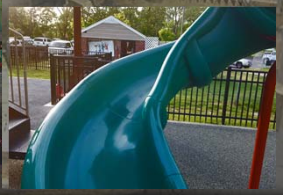
Municipal Playground Slide

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Municipal Playground Slides


- Slides – Sectional not modular
- Very robust
- Concealed hardware
- Very plain – basic designs
- Excellent alignment between sections

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Original Specifications

- Slide will be marketed to the residential market.
- Slide will be rotationally molded as one modular section of a spiral which can be indefinitely attached to itself forming a left or right handed spiral.
  - 3 sections = 270° x 5 foot high spiral
  - 4 sections = 360° x 7 foot high spiral
  - 5 sections = 450° x 9 foot high spiral
- The slide will be designed for a .160" nominal wall
- The slide will include a specially designed arched entry section to fit to any height tower.
- The exit section will be designed such that the slide surface is approximately one foot off the ground.
- Total number of molds = 4 for a right or left hand spiral

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Specific Details for Final Design

- Interface details to the tower
- Attachment of one section to the other.
- Tolerance and alignment assessment
- FEA Structural analysis based on defined loads and attachment points
- Safety analysis
- Compliance with regulatory specifications
- Moldability and tolerance analysis
- Cost assessment for molds and parts
- Details for entry and exit modules

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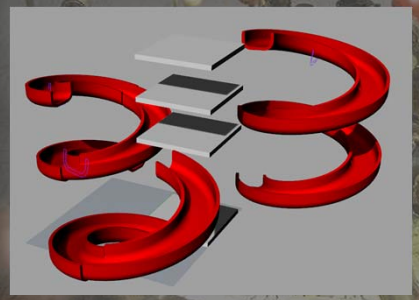
Calculate Module Dimensions



First study focused on determination of module dimensions

- Angular section
- Diameter
- Pitch
- Cross section

to comply with tower height increments, entry point and exit directions

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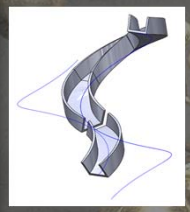
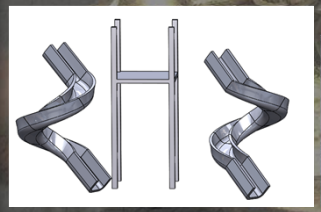
Initial Studies of Spiral



Discovery:

Open spiral slide can only be right or left hand. Cannot mate surfaces contiguous flowing spiral with left and right hand from same modules



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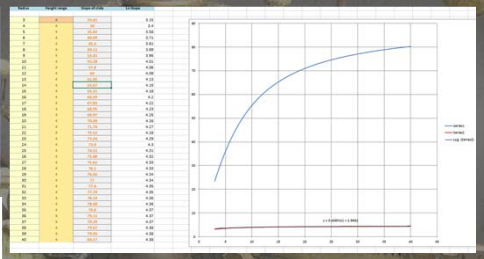
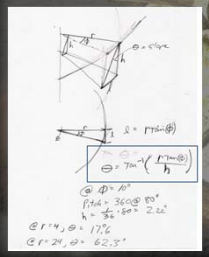
Calculation of Slope vs. Diameter





ROUND(DEGREES(+ATAN((A14*(TAN(6.283185*(B14/48))/B14)))),2)

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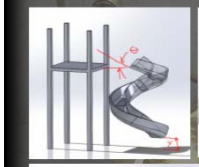
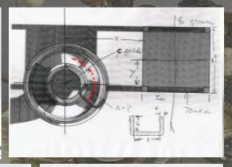
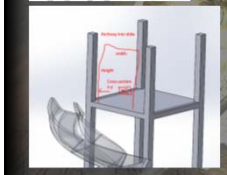
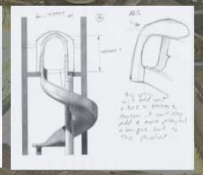
Early Layout Studies









Examined basic design criteria

- Entry slope angle
- Spiral diameter
- Overall slope, speed and safety
- Slide & tower assembly
- Archway entry geometry
- Direction of slide

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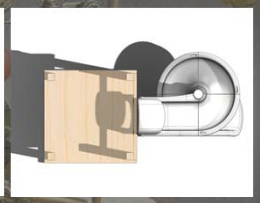
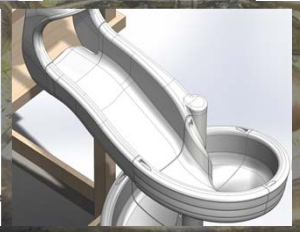
Early Concepts of Slide





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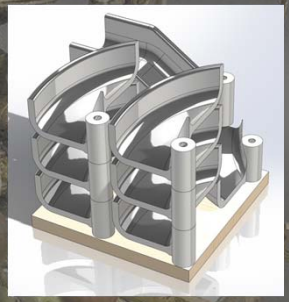
Palletizing Study



Pallet stacking studies for minimum and maximum size slide configurations

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Concept Sketches for Entry

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Final Design

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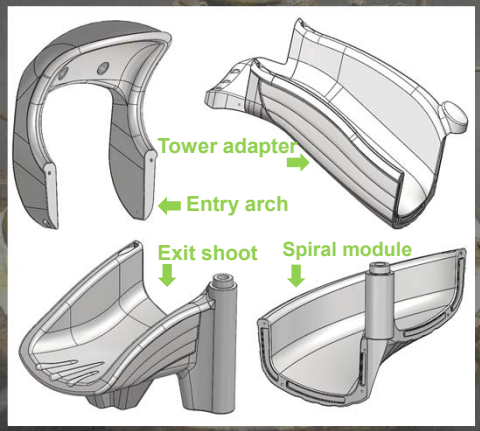
Modules



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Entry Arch

- Hood provides a safety feature for children entering slide as well as an appropriate aesthetic entry point
- Mounting features provided secure attachment to tower
- Clean planar surface was designed to mate to tower adapter
- All surfaces were meticulously designed to balance aesthetics and function with ease of molding. Draft was added in all critical areas

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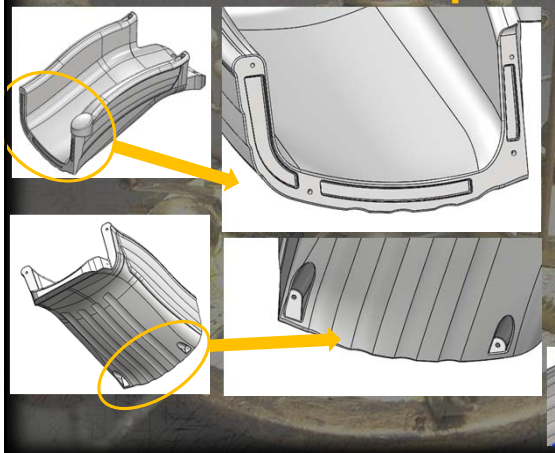
Tower Adapter



Tongue in groove interlocks provided self aligning features for modular sections

Molded recesses and holes were designed to comply with aesthetics, processing and ease of assembly.

Cross sections were checked for 5:1 ratio

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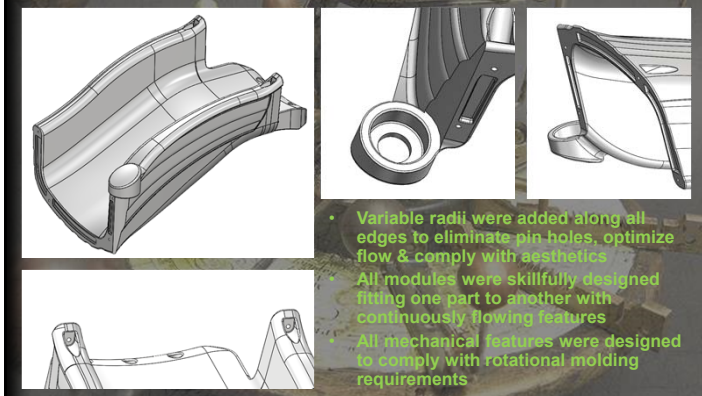
Tower Adapter



- Variable radii were added along all edges to eliminate pin holes, optimize flow & comply with aesthetics
- All modules were skillfully designed fitting one part to another with continuously flowing features
- All mechanical features were designed to comply with rotational molding requirements

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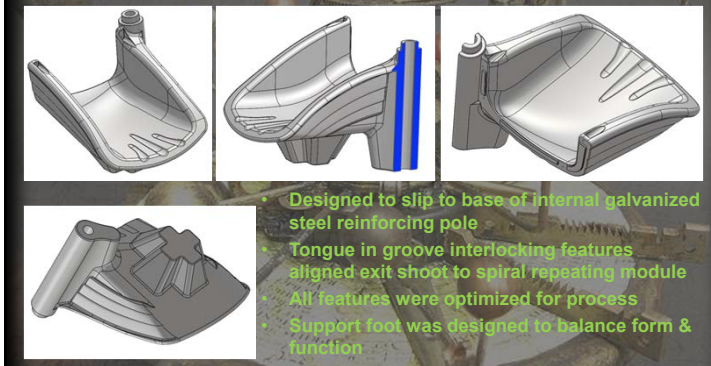
Exit Shoot



- Designed to slip to base of internal galvanized steel reinforcing pole
- Tongue in groove interlocking features aligned exit shoot to spiral repeating module
- All features were optimized for process
- Support foot was designed to balance form & function
- Fluted styling lines were detailed to align with modules and gracefully terminate the slide

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Spiral Module

Complicated intersection of center post collar and spiral module: optimize

- Function
- Form
- Structure
- Ease of molding

Critical interface between sections:

- Smooth transition between sections
- Tolerance control
- Secure fastening
- Ease of molding

¾” between walls @ .160” wall.
5 x .160 = .80” ..OK

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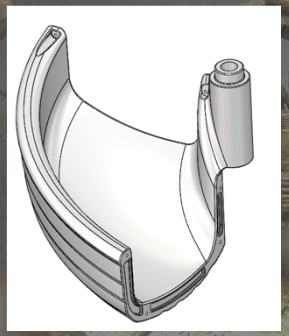
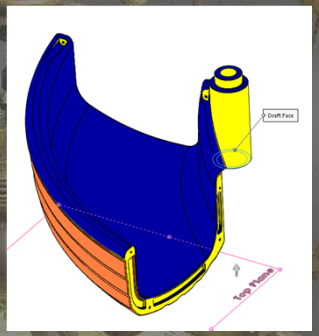
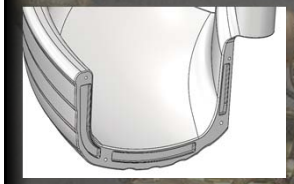
Draft Review

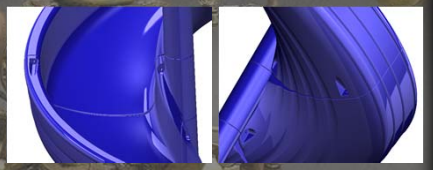


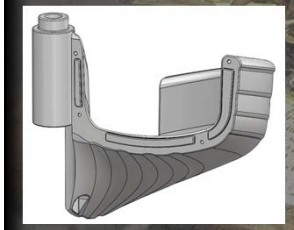


- Part geometry was refined to balance aesthetics with draft angles and molding requirements
- Four part mold was required to maintain perpendicular faces with interlocking features on both sides
- Center post collar was only partially cored on top and bottom. No draft on exterior surfaces

Mating Sides of Spiral Module







- Mating sides of module were designed to perfectly fit to adjacent mating parts forming a contiguous spiral on inside and outside surfaces
- Trailing edges of interior surfaces were slightly modified to assure slide would cascade without interruptions
- Locking self forming bolts were specified to prevent loosening and a secure assembly

Finished Product

Started True Form Plastics

Winner of Best New Product

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