

## Preparing Tire Tread Models in Coreform Cubit



### **Many-to-one Sweep**







## Many-to-one Sweep

- Coreform Cubit is a *semi-automated* hex-mesher
  - Means that Cubit can recognize certain topologies as meshable without further decomposition by the user
- A "many-to-one sweep" (N:1) is one of the techniques that can recognize topologies as meshable
- Importantly, whenever an N:1 sweep is used, you *could* have done additional decompositions to make multiple 1:1 sweeps





### **Many-to-one Sweep**







### **Manual decomposition**





## **Tire tread geometry**

#### Single "unit" of tread with symmetry

Full tread pattern





## **Separating into subunits**

- When dealing with complex models, it's often helpful to cut the model into simpler subunits and process individually
  - Export each subunit to unique ACIS file
  - Process each model to obtain mesh, save as CUB5
  - Import all CUB5 and apply final operations for global meshability







## Overview

• This section doesn't require any cleanup to produce an N:1 mesh





Command Panel					Ċ'	
🗲 🔛 🕨 Mesh 🕨	/olume 🕨 Me	sh 🕨 Swe	ep			
Select Volumes						
1						
Specify Source ar	nd Target					
<ul> <li>Auto Select Source</li> </ul>	te and Target	t				
Source Surface ID(s)	151 17 90 92	2 89 148 1	72			
Target Surface ID	19					
O Default	) Extrude		⊖ Ad	vanced		
Redistribute Nodes	;					
Transform Method		Least Squ	ares		~	
Propagate Bias						
Parallel Meshing E	inabled					
Automatically Smo	ooth the Targ	et Surface	2			
Fixed Imprints	Smart Sr	mooth				
Tolerance	0.2					
Number of Layers	5				*	
				Apply S	cham	
				Apply 2	criciti	
Check For Overlap	ping Surfaces	;				
Apply Scheme Before	ore Meshing					
Scheme: sweep				Mes	sh	









### **Mesh quality** Note that the poor elements tend to be caused by "linking" between sweep layers 0.998 0.838 0.678 0.517 0.357 t



## **Group assingments**

- When meshing using this "by-section" approach, it can be useful to add any sweep assignments to groups
- This will allow for easily reassigning mesh commands when recombining all the sections together
- When finished save as a CUB5
- Do this process for each section







## Overview

• This section will require a few composite operations, to convert challenging-to-mesh surfaces into simpler topology





- Many sipes have rounded features such as shown on the right
- These pose a challenge for meshing as the linking curves for our eventual sweep become perpendicular to the sweep direction *and* form a singularity between three surfaces





- Compositing the three surfaces into a single curve allows Cubit to ignore the troublesome *topology*.
- When placing elements & nodes, Cubit will still evaluate the underlying surface geometries (i.e., shape), just has the freedom to ignore the topology







Command Panel	8 ×
Geometry > Surface > Modify >	Composite
Surface ID(s) 65 87 64	
Select	
O Create O Delete	
Max Surface Angle	
Composite Bounding Curves	
Keep Vertex ID(s)	
Max Curve Angle 15	
Virtual Geometry	
(j) <b>?</b>	Apply





📽 Cubit — 🗆 🗙		Cubit - 🗆 X
	Command Panel 🗗 🗙	
	Geometry > Curve > Modify > Composite	
	Curve IDs 234 235	
	Select	
	• Create O Delete	
	Keep Vertex ID	
	Max Curve Angle	
	Virtual Geometry	











## Smoothing





Command Panel			6	×
See See Mesh > Volume	Quality      Quality Metrics			
Volume ID(s)	1			
Quality Metric		Scaled Jacob	pian	$\sim$
Summary Options				
<ul> <li>Combined Summary</li> </ul>				
One Summary Per Entity	/			
Filter Element Quality Ran	nge			
Filter Using Element Quali	ty Rank			
🕑 Display Graphical Summar	у			
🕑 Draw Mesh Elements				
Draw Histogram				
Monochrome				
< Clear Display for Mesh				
Print Text Summary				
(i) <b>?</b>		(	Apply	





- Note that the sloped surface results in relatively poorly shaped elements, but this element quality isn't too bad
- The less perpendicular the surface, the more elements need to deform to conform, resulting in worse element quality







## Overview

 This section is nearly identical to the second section, requires similar processing to produce an N:1 mesh











## Overview

- This model has a sliver that was made to ensure vertical surfaces on the symmetry surfaces
- This sliver would *enforce* poor element quality but we can move the geometry back to the other side and make a better "symmetry cut"
- This, combined with some other cleanup will then allow us to make an N:1 sweep





## **Initial Cleanup**





## **Overview of the new cut**

#### • Goal:

 We want a curve that will allow us to sweep in the –Z direction, approximately in-between the two nearly-vertical surfaces





## **Create offset surface**

#### • Step 1:

• Create an offset surface approximately, will retain the general shape of the surface

Command Panel		8	×
🧲 <b>ð i</b> Geome	try 🕨 Surface 🕨 Create 🕨 Offset		
From Surface ID(s)	22		
Offset Value	2		
Ор	tional Surface ID(s)/Offset Pairs		
Surface ID(s)			
Offset Value			
Surface ID(s)			
Offset Value			
Surface ID(s)			
Offset Value			
(i) 🥠	Preview Ap	ply	





## **Create extended surface**

#### • Step 2:

- Create an extended surface, extended from the offset surface.
- By default the extended surface extends to extent of total bounding box – which is why it was helpful to split the part into sections

Command Panel		8	×
Geometry )	Surface + Create + Extended Surface		
	· · · · · · · · · · · · · · · · · · ·		
Surface ID(s)	172		
🗌 Intersecting Entity L	ist		
Extended Value			
Percentage			
Absolute			
(j 🥠	Preview	oly	





## Webcut sweep curve

- Step 3:
  - Sweep the top curve of the extended surface, in the –Z direction

Command Panel	Ð	×
Geometry > Volume >	Webcut 🕨 Sweep Curve	
Volume ID(s) 1		
Curve ID 490		
Direction		
<ul> <li>Vector</li> </ul>	O Along Curve	
O Rotate About Axis		
Vector 0 0 -1		
Distance		
End Conditions		
Through All		
To Surface		
Group Results		
(j) <b>?</b>	Preview Apply	





### Webcut sweep curve





## Move chopped volume

#### • Step 4:

 Now we want to move the volume to the other side of the volume – a distance 29.42 in the +X direction

Command Panel		đΧ
Geometry I	Volume   Transform  Move	
Volume ID(s)	1	
Include Merged Select Method		
<ul> <li>Distance</li> </ul>	🔿 To Entity	
To Coordinates In Direction Of Su	General Location	
Distance 29.42		
/ Distance		_





## Unite into single volume

#### • Step 5:

• We can then safely unite the volumes back into a single volume






### **Composite surfaces**

- The geometry modification completed, we now composite extraneous surfaces into macro surfaces
- Sometimes can be done as a single operation on all surfaces

Command Panel		Ð	×
🤄 💉 Geome	try > Surface > Modify > Composite		
Surface ID(s) all			
Select			
Create	O Delete		
Max Surface Angle	1		
🔽 Composite Bou	nding Curves		
Keep Vertex ID(s)			
Max Curve Angle	15		
Virtual Geometry			
(i) <b>?</b>		pply	





### **Composite surfaces**

• Ignored curves will be shown as a dashed line





### **Generate many-to-one mesh**





# **Meshing Section 5**



### Overview

- The most complicated section, we need to use all the tools:
  - 1. Rechop to remove sliver feature
  - 2. Geometry cleanup
  - 3. Virtual topology
  - 4. N:1 meshing





## **Chop off the sliver**

- We use the same approach as for section 4 to chop and recombine the sliver region
- Note here that the offset and extended surfaces are tall and, due to their angle, the top curve isn't over the desired cut surface





## **Chop off the sliver**

 So we'll trim the extended surface to give ourselves a curve that we *can* use for our cut

Command Pane	1		8	×
🕞 🗊 🕨 Geon	netry 🕨 Volume 🕨 We	ebcut 🕨 Coordinate Plane		
Volume ID(s) 3				
⊖ yz	⊖ zx	<b>O</b> XY		
Offset Value 1				
C Rotate Plane				
Imprint				
🗌 Include Neighb	oors			
Merge				
Group Results				
(i) 🔨		Preview Ap	ply	





## **Chop off the sliver**

• Then we do our same webcut approach as before





### Move the chopped surface





### **Recombining & cleanup**

#### • Goal:

- Some CAD modeling errors can be seen prior to us re-uniting the volumes
- We want to clean up these mistakes
  - You could ask the CAD designer to fix in native CAD software
  - Or you can fix yourself using Cubit's direct modeling engine





### Chop off extra block

• Create a surface by sweeping the fillet's curve in the +X direction

Command Panel		×
🚰 🍞 🕨 Geometry 🕨 Surface	• Create • Sweep	
Curve ID(s) 347		
Sweep Method		
Along Curve	◯ Helix	
<ul> <li>Vector And Distance</li> </ul>	O Target Body	
Axis/Angle		
Vector X,Y,Z 100		
Distance 10		
Include Mesh		
Delete Source Curve		
(i) <b>•</b>		Apply





### Chop off extra block

• Then we can use a webcut using the plane of this surface to begin trimming this region away

Command Panel
Geometry ► Volume ► Webcut ► Plane Surface
/olume ID(s) 1
Plane From Surface ID 140
Group Results
Preview Apply





### Chop off extra block

• Next we chop off the "tower" part of the block by the plane defined by the base surface

Command Panel	×
Geometry > Volume > Webcut > Plan	ne Surface
Volume ID(s) 1	
Plane From Surface ID 122	
Group Results	
(j) <b>?</b>	Preview Apply





### **Delete the volume & tools**

Command Panel	×
Geometry > Volume > Delete	
Volume ID(s) 2 3 4 6 8	
Keep Lower Geometry	Analy
	Apply





### **Reunite volumes**

Command Panel	×
Geometry > Volume > Boolean > Unite	
Volume ID(s) all	]
C Keep Originals	
🗌 Include Mesh	
(i) <b>?</b>	Preview Apply





### **Remove sliver surface**

Cubit	– 🗆 X	€ Cubit - □ X
$\sim$	Command Panel	
	Geometry ► Surface ► Modify ► Remove	
	Extend	
	Remove Blend Chain	
	Remove Cavity	
	Remove Individually	
	Remove Connected Sets	
	(i) 🥠 Preview	Apply



### **Cleanup extraneous surfaces**

- Sometimes these operations result in nearly-equivalent surfaces that are only different due to numerical noise
  - For example, face normals that are 1e-12 different, so that a "regularize" command won't clean them
- When these surfaces will eventually be shared between the different model sections, you may choose to use compositing
- When the surfaces won't be shared, you may wish to use the "remove extend" approach to create *real* geometry changes





### **Continuing CAD Cleanup**

- It appears that the designer's modifications to create the original repeat unit cell resulted in a few more errors
- We need to remove the sliver surface that is caused by the fillet being cylindrical rather than conical





### **Remove the offending surfaces**





## Add a new fillet

- Since Cubit doesn't have the ability to directly modify the original fillet to match the (nearly) conical shape, we will instead create a new fillet
- This **is** changing the geometry, though very slightly
  - The best approach would have been to bring up these modeling issues to the original CAD designer





### **Remove extraneous surface**

- Again, cleanup extraneous surfaces
  - Even though we will be removing this surface, by cleaning it we will improve the robustness of forthcoming operations

Command Panel	×
Geometry > Surface > Modify > Ren	nove
Surface ID(s) 51	
Extend	
Remove Blend Chain	
Remove Cavity	
Keep Surface	
Keep Copy Of Original	
Remove Individually	
Remove Connected Sets	
(j) <b>?</b>	Preview Apply





#### • Goal:

• We want to remove the ledge feature, resulting in a full-length fillet

#### • Strategy:

 Create a surface that can be swept and Boolean subtracted to leave the fillet







- Step 1:
  - Create a minimal plane

Command Panel	x
Geome	try > Surface > Create > Vertex List
Select	
Vertex ID(s)	103 105 82
○ Node ID(s)	
On Surface	
Surface ID	
Project	
(j) 🤊	Apply





#### • Step 2:

• Create a plane surface by sweeping the curve so that it extends beyond the outer surface

Command Panel		×
Geometry > Surface	Create Sweep	
Curve ID(s) 155		
Sweep Method		
O Along Curve	◯ Helix	
Vector And Distance	O Target Body	
O Axis/Angle		
Vector X,Y,Z 100		
Distance 10		
Include Mesh		
Merge Results		
Delete Source Curve		
🗌 Rigid		
(j) <b>9</b>		Apply





- Step 3:
  - Create a vertex on the target surface's outer curve

Geometry 🕨 Vert	ex ► Create ► On Curve	
Curve ID(s) 128		
Specify Location Using		
Fraction	O Close To Vertex	
O Distance	At Location	
O Position	◯ Extrema	
🔾 Start	O Segments	
O Midpoint	<ul> <li>Discontinuities</li> </ul>	
O End	Crossing	
Cross		
O Curve		
<ul> <li>Surface</li> </ul>		
Surface ID(s) 54		
Bounding		
O Bounded		
() Near		
Pick Color default		





- Step 4:
  - Partition the target surface through the two vertices

Command Panel	×
Geometry + Surface + Modify + Split	
Through Vertex	~
Surface ID(s) 46	
Through Vertex ID(s) 108 114	
(j) <b>?</b>	Preview Apply





- Step 5:
  - Create a volume by sweeping the target surface along the outer curve

Command Panel	N Create N Sween	
urface ID(s) 55	V Create V Sweep	
	🔿 Target Volume	
Along Curve	O Target Plane	
Along Vector	O About Axis	
O Direction	⊖ Helix	
urve ID(s) 145 Individual Volumes		
Merge Results		
Delete Guide Curves		
Delete Source Surfaces		
i) 🥠		Apply





#### • Step 6:

 We suspect that there will be small CAD features introduced if we were to Boolean subtract, so to minimize we extend the volume to at least remove one potential

#### issue

Command Panel		×
Geometry > Volume > Mod	lify 🕨 Extend by Sweep	
Note: This panel extends unmeshe	d geometry only.	
Surface ID(s) 59		
O Perpendicular	O Target Plane	
O Along Curve	O About Axis	
Along Vector	◯ Helix	
Vector X,Y,Z 100		
Distance (Optional)		
🗌 Draft Angle		C Rigid
Draft Type O Extend O Round	ł	
(j) 🥠		Apply





- Step 7:
  - Subtract the tool volume
  - This leaves a little pocket which we will need to cleanup





#### **Overview of pocket**



Detail







### **Taking stock of progress**





### **Reviewing symmetry model**





## **Recovering symmetry**

#### • Goal:

• Recover symmetry by making the ledges on both sides match





### **Recovering symmetry**

- Step 1:
  - Create copy of the target curve on our current working surface

r	
Command Panel	×
Geometry > Curve	Create      Copy and Transform
Curve ID(s) 194	
Transform Copied Curves	
O Move	○ Reflect
○ Rotate	◯ Scale
X <u>-29.42</u> Y Z	
Repeat	
Group Results	
Copy Mesh	
Copy Boundary Conditions	
(j) <b>?</b>	Preview Apply





## **Recovering symmetry**

#### • Step 2:

• Use the two vertices from the new curve and one vertex on the original curve to define a cut plane

Command Panel ×
Geometry > Volume > Webcut > Plane Vertex
Volume ID(s) 1
Vertex 1 ID 148
Vertex 2 ID 147
Vertex 3 ID 105
Group Results
(i) I Preview Apply




#### • Step 3:

 Begin chopping off the region to remove, here extending one of the base surfaces

Command Panel
G T « Volume > Webcut > Sheet Extended From Surface
Volume ID(s) 1
With Surface ID(s) 85
Group Results
(i) 🥎 Preview Apply





#### • Step 4:

• Continue chopping off the region to remove, here extending other base surface

Command Panel	ĸ
G T « Volume > Webcut > Sheet Extended From Surface	
Volume ID(s) 6	1
With Surface ID(s) 112	
Group Results	
(i)  Preview Apply	)





- Step 5:
  - Subtract the extraneous volume
- Step 6:
  - Unite the volumes









- Now we have finished fixing the geometry
- Next, we will go through the model and composite surfaces to support a quality mesh





### **Result of compositing**





- While we could build an N:1 mesh on the remaining volume, there's enough source surfaces that it makes sense to split into three sections to make things a bit more manageable
- Also provides a little bit of rigidity to the mesh that helps with robustness and quality





#### • Step 1:

- Apply "Sheet Extended From Surface" webcut, using 2 surfaces
- The resulting webcut will use the trimmed extensions of these surfaces (note the angle)

Command Panel	×
G T « Volume > Webcut > Sheet Extended From Su	urface
Volume ID(s) 1	
With Surface ID(s) 8 29	
Group Results	
(i) 🧿 Preview	Apply





- Step 1:
  - Apply "Sheet Extended From Surface" webcut, using 1 surface









# **Recombine and Create Unified Mesh**



### Import each section



Note that these meshes are not contiguous at their boundaries. We will need to imprint and merge these volumes with each other and remesh!



### **Create Contiguous Mesh**





#### **Refining the mesh** Command Panel 🔚 🖶 🕨 Mesh 🕨 Volume 🕨 Refine 🕨 General Refinement Volume ID(s) Refinement Condition Split Iterations O Target Size 1.0 Refinement Boundary Element Depth Refinement Radius Smooth (i) **1** Apply While you *could* use a finer mesh size at

the time of creation, I find that sometimes it's faster and more robust to mesh coarse and then refine to the desired size – especially when using N:1 sweeps



### **Reviewing the model**





### **Reviewing the model**





### **Reviewing the model**

