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Sculpt Test Problem Analysis

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Abstract

This report details Sculpt's implementation from a user's perspective. Sculpt is an automatic hexahedral mesh generation tool developed at Sandia National Labs by Steve Owen. 54 predetermined test cases are studied while varying the input parameters (Laplace iterations, optimization iterations, optimization threshold, number of processors) and measuring the quality of the resultant mesh. This information is used to determine the optimal input parameters to use for an unknown input geometry. The overall characteristics are covered in Chapter [1](#). The specific details of every case are then given in Appendix [A](#). Finally, example Sculpt inputs are given in [B.1](#) and [B.2](#).

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Chapter 1

Introduction

Sculpt is an automatic mesh generation software developed at Sandia by Steve Owen. This report demonstrates Sculpt's meshing performance on 54 test cases, each with a different geometry. Though Sculpt has the capability of creating tetrahedral meshes, this report only considers pure uniform hexahedral meshes.

Purpose

The purpose of this report is to provide the reader with a reference on Sculpt's current performance across a wide variety of geometries and input parameters. For each geometry (test case), the following input arguments are varied:

- Optimization Iterations
- Laplace Iterations
- Optimization Threshold
- Number of Processors

Smoothing iterations are defined as the number of optimization iterations + the number of Laplace iterations. Sculpt requires a size value for the overlay grid. This was found previously by completing an exhaustive search of possible values. As a result, each test case has a known unique ideal size value. The output metrics for each mesh are:

- The lowest quality element
- The number of low quality elements
- The elapsed time to create the mesh

Within this report, element quality is measured using the element's scaled Jacobian. Though much assistance was provided from Sculpt's developer, the following report demonstrates Sculpt's implementation from a user's perspective.

The primary purpose of studying all these input arguments is to develop an idea of what input parameters should be used for an unknown mesh. That is, what input parameters are most likely to yield the best results. In order to accomplish this, the behavior of the mesh based on the input arguments is also studied. Here, the best results are considered to be the mesh with the highest low quality element that meshes in an acceptable amount of time.

For reference, example journal files of how the 54 cases were executed is included for two of the cases in [B.1](#) and [B.2](#). For information detailing how Sculpt works, Sculpt's input file options, and more information on Sculpt's performance, see [\[1\]](#), [\[2\]](#).

Chapter 2

Overview

Within this report, 54 test cases (i.e. 54 different geometries) are meshed with various input arguments and Sculpt’s performance is evaluated for each case. Each test case is meshed with various combinations of optimization iterations, Laplace iterations, optimization thresholds, and executed using a variable number of processors. For values used, see Section 2.

Using the average element quality of a mesh as a metric for how good a mesh is can be somewhat misleading. Sculpt produces meshes with an average element quality that is typically fairly high. Further, the lowest quality element(s) are the limiting factor for further analysis. As a result, for the purposes of this report, mesh quality refers to the scaled Jacobian of the **lowest** quality element.

The ideal input parameters for a specific test case are assumed to be those used in the highest quality mesh. That is, the mesh with the highest low-quality element. These ideal parameters are studied in Section 2. and the distribution of the ideal values is given in Figure 2.2, Figure 2.3, and Figure 2.4.

However, simply studying the input parameters leading to the highest quality mesh for each case doesn’t provide sufficient information to select the best input parameters for an unknown case. Even though a specific case has a certain combination of ideal input parameters (say **A**), this same case may have very little reduction in quality when another set of values (say **B**) is chosen. However, another case may have a very poor quality at the first set of values (**A**), with its best quality occurring at the second set of values (**B**). In this example, the second value (**B**) would likely be the better choice. Thus, the affect the input parameters on **all** test cases is presented in Figure 2.5, Figure 2.6, and Figure 2.7 (and repeated with a different definition of low/medium/high quality in Figure 2.8, Figure 2.9, and Figure 2.10)

An overview of all cases is provided in Section 2. With this information, the ideal default parameters are discussed in Chapter 3. The charts below contain a summary of all 54 test cases. For further reference, all of the data from each individual test case is included in Appendix A. In Appendix A, each case contains plots showing the effect of the input parameters on the minimum element quality, the number of bad elements, and the time taken to complete. Each data point in these charts represents **one** mesh. That is, one combination of input parameters leading to a single mesh is summarized with a single point

on each chart. There are 840 different meshes (all combinations of input parameters, see Section 2) for each test case. Therefore, there are 840 different data points in each plot in this section. This section can be used to see observe the effect of the input parameters on cases with various geometries and ideal mesh qualities.

Notes

- Each test case had 840 different combinations (5 Laplace iteration values $\times$ 7 optimization iterations values $\times$ 3 optimization threshold values $\times$ 8 number of processors values)
- 45,360 different cases tested in all ($= 840 \times 54$)
- Parameters for Test 56
  - 5 Laplace Iterations: $[0,1,\dots,4]$
  - 7 Optimization Iterations: $[4,5,\dots,10]$
  - 3 Optimization Threshold: $[0.40,0.45,0.50]$
  - 8 Number of Processors: $[1,2,\dots,8]$
- Platform: All meshing was completed on a Linux blade with 8 cores and 16Gb of RAM

Summary Plots and Tables

A summary of all cases is provided below. To determine the ideal parameters for each test case, the maximum low quality element (of the 840 meshes) was found and the input parameters leading to this are shown below.

Ideal Parameters for All Cases					
Case Name	Autosize	L It	O It	O Th.	Min SJ
a027	0.350	4	4	0.40	0.303
a045a	1.700	4	7	0.40	0.337
a901	1.350	2	5	0.40	0.327
a_trol02	1.900	4	8	0.50	0.195
anc101	0.050	3	6	0.50	0.208
andy_hilbert	0.900	2	4	0.40	0.220
bbl1	0.450	1	6	0.40	0.144
body	1.100	2	7	0.40	0.172
bolzen	1.550	4	4	0.40	0.571
browell1	1.450	4	6	0.45	0.460
cad6	0.200	4	8	0.50	0.227
cam	2.000	2	4	0.50	0.197
chainr5	1.500	2	6	0.40	0.282
cognit	1.550	3	6	0.40	0.137
cone	0.550	3	5	0.40	0.357
coneorig	1.600	4	5	0.45	0.345
cover	0.850	2	5	0.40	-0.075
crankr3	1.650	4	6	0.45	0.225
ctube	0.950	2	9	0.50	0.206
cylinder	0.800	1	5	0.45	0.394
demo05	1.800	0	9	0.50	0.262
disk	1.500	1	6	0.50	0.233
displacedblock-01	1.500	4	4	0.45	0.498
driver	1.500	3	8	0.40	0.150
engine2	1.200	2	8	0.40	0.168
explorer_part	1.300	4	7	0.45	0.300
fender_done	0.550	0	9	0.40	0.178
funnel	1.050	4	5	0.40	0.187
goose16	1.800	1	6	0.50	0.260
handlex2	0.650	1	8	0.45	0.268
keg_ds	1.200	4	5	0.50	0.378
lamb	0.750	0	10	0.40	-0.874
lever_part	0.200	4	5	0.50	0.353
lt-vhs	1.300	0	10	0.45	0.185

Ideal Parameters for All Cases (cont.)					
Case Name	Autosize	L It	O It	O Th.	Min SJ
m51	1.650	2	10	0.40	0.177
part29	0.050	4	7	0.50	0.254
plunger	1.500	4	4	0.50	0.347
pump	1.650	1	10	0.40	0.111
quatercubewhole	1.550	3	5	0.50	0.321
railsupport	1.000	3	9	0.45	0.298
rib2a	1.700	4	8	0.50	0.302
rim_done	2.000	2	7	0.50	0.158
rocker	1.100	3	9	0.45	0.136
sbase1	1.450	4	4	0.50	0.329
spdlbrk2	1.700	1	8	0.50	0.209
sphere	1.700	4	5	0.50	0.349
spindle4	1.150	1	9	0.50	0.314
sprayer	1.000	4	9	0.50	0.354
std_3ax	1.650	4	5	0.45	0.235
test_1	1.750	3	9	0.40	0.011
trane	0.450	2	6	0.40	0.158
varco2	1.300	4	10	0.50	0.355
wizard-stress_part	0.500	2	5	0.45	0.298
yoke_male	0.750	4	5	0.50	0.454

Figure 2.1: Summary of the best meshes achieved for each of the 54 test cases. Note: Good was considered any case where the minimum mesh quality was greater than 0.2. Poor cases had a mesh quality greater than 0 and bad cases had a negative mesh quality

Figure 2.2: The Laplace iterations resulting in the maximum mesh quality for each case. The x-value represents the number of Laplace iterations and the y-value represents the number of test cases in which that specific number of Laplace iterations achieved maximum quality. Therefore, the sum of all the bars is equal to 54.

Figure 2.3: The optimization iterations resulting in the maximum mesh quality for each case. That is, for each case, the ideal number of optimization iterations was found and added to the respective bin above.

Figure 2.4: The optimization thresholds resulting in the maximum mesh quality for each case.

Figure 2.5: The highest mesh quality achieved at each value of Laplace iterations. The best mesh quality is found for each test case and plotted in the low, medium, or high quality category. Note: The sum of the three bars at any value of Laplace iterations equals the total number of cases (i.e. 54).

Figure 2.6: The highest mesh quality achieved at each value of optimization iterations. The best mesh quality is found for each test case and plotted in the low, medium, or high quality category. Note: The sum of the three bars at any value of optimization iterations equals the total number of cases (i.e. 54).

Figure 2.7: The highest mesh quality achieved at each optimization threshold value. Note: The sum of the three bars at any value of the optimization threshold equals the total number of cases (i.e. 54).

Figure 2.8: The highest mesh quality achieved at each value of Laplace iterations. The best mesh quality is found for each case and plotted in the low, medium, or high quality category. Note: The sum of the three bars at any value of Laplace iterations equals the total number of cases (i.e. 54).

Figure 2.9: The highest mesh quality achieved at each value of optimization iterations. The best mesh quality is found for each test case and plotted in the low, medium, or high quality category. Note: The sum of the three bars at any value of optimization iterations equals the total number of cases (i.e. 54).

Figure 2.10: The highest mesh quality achieved at each optimization threshold value. Note: The sum of the three bars at any value of the optimization threshold equals the total number of cases (i.e. 54).

Chapter 3

Conclusion

Default Input Parameters

As mentioned above, a major goal has been to determine the ideal default (or possibly, starting) input parameters to use. Once a favorable input parameter value is found, the CPU time is checked to ensure that it is not prohibitively large. With this in mind, the following default values were chosen:

- Laplace iterations: 2 (Based on Figures [2.5](#), [2.8](#))
- Optimization Iterations: 10 (Based on Figures [2.6](#), [2.9](#))
- Smoothing Iterations: 12 (optimization iterations + Laplace iterations)
- Optimization Threshold: 0.45 (Based on Figures [2.7](#), [2.10](#))

Regardless of the number of iterations used, both the Laplace and optimization iterations have a large effect on the distribution of meshes. In both cases, the spread from the lowest mesh quality to the highest mesh quality decreases with increased numbers of iterations. Further, the time increase from using more iterations (Laplace or optimization) is very small in comparison to the total run time. This may be expected for cases with only high quality elements (since most elements are above the threshold), but surprisingly, this was also observed in cases with lower quality elements. As a result, it was not necessary to take time into account when selecting the ideal values.

Within the cases tested, Sculpt performed extremely well with 67% of the meshes having a minimum element scaled Jacobian greater than 0.2 and only 4% having a scaled Jacobian less than zero. In terms of performance, Sculpt demonstrated excellent parallel characteristics with close to a 50% reduction in compute time whenever the number of cores were doubled.

Future Work

A problem frequently encountered was the inability to measure the error in volume. As autosize was increased (increasing the size of the overlay grid), the minimum element quality also increased. This was found to be caused by the finer details of the geometry being smoothed over. A basic search for the best size to use may result in a single element mesh. It is for this reason that the mesh needs to be penalized for not accurately representing the original geometry. A function to measure the difference between the geometry and the mesh would likely be useful.

To understand the applicability of the 54 included test cases, it may prove worthwhile to begin meshing more parts using the default parameters found above. This will show how applicable the 54 test cases are to those currently being studied here at Sandia.

References

- [1] StevenJ. Owen and TimR. Shelton. Validation of grid-based hex meshes with computational solid mechanics. In Josep Sarrate and Matthew Staten, editors, *Proceedings of the 22nd International Meshing Roundtable*, pages 39–56. Springer International Publishing, 2014.
- [2] StevenJ. Owen, MatthewL. Staten, and MargueriteC. Sorensen. Parallel hexahedral meshing from volume fractions. *Engineering with Computers*, pages 1–13, 2012.

Appendix A

Case Details

A.1 a027

Figure A.1: Highest quality mesh with each element colored by scaled Jacobian

a027: Ideal Parameters	
Minimum Mesh Quality	0.30
Smoothing Iterations	8
Laplace Iterations	4
Optimization Iterations	4
Optimization Threshold	0.40
Autosize Value	0.35
Number of Combinations Tested	840

Figure A.2: a027: Meshing parameters plotted against the minimum scaled Jacobian mesh quality for each case

a027: Number of Poor Quality Elements with Smoothing Iterations

a027: Number of Poor Quality Elements with Optimization Iterations

a027: Number of Poor Quality Elements with Laplace Iterations

a027: Number of Poor Quality Elements with Optimization Threshold

Figure A.3: a027: Meshing parameters plotted against the number of bad quality elements. Here, a bad quality element is defined as any element with a negative scaled Jacobian

Figure A.4: a027: Meshing parameters plotted against the simulation run time

A.2 a045a

Figure A.5: Highest quality mesh with each element colored by scaled Jacobian

a045a: Ideal Parameters	
Minimum Mesh Quality	0.34
Smoothing Iterations	11
Laplace Iterations	4
Optimization Iterations	7
Optimization Threshold	0.40
Autosize Value	1.70
Number of Combinations Tested	840

Figure A.6: a045a: Meshing parameters plotted against the minimum scaled Jacobian mesh quality for each case

a045a: Number of Poor Quality Elements with Smoothing Iterations

a045a: Number of Poor Quality Elements with Optimization Iterations

a045a: Number of Poor Quality Elements with Laplace Iterations

a045a: Number of Poor Quality Elements with Optimization Threshold

Figure A.7: a045a: Meshing parameters plotted against the number of bad quality elements. Here, a bad quality element is defined as any element with a negative scaled Jacobian

Figure A.8: a045a: Meshing parameters plotted against the simulation run time

A.3 a901

Figure A.9: Highest quality mesh with each element colored by scaled Jacobian

a901: Ideal Parameters	
Minimum Mesh Quality	0.33
Smoothing Iterations	7
Laplace Iterations	2
Optimization Iterations	5
Optimization Threshold	0.40
Autosize Value	1.35
Number of Combinations Tested	840

Figure A.10: a901: Meshing parameters plotted against the minimum scaled Jacobian mesh quality for each case

a901: Number of Poor Quality Elements with Smoothing Iterations

a901: Number of Poor Quality Elements with Optimization Iterations

a901: Number of Poor Quality Elements with Laplace Iterations

a901: Number of Poor Quality Elements with Optimization Threshold

Figure A.11: a901: Meshing parameters plotted against the number of bad quality elements. Here, a bad quality element is defined as any element with a negative scaled Jacobian

Figure A.12: a901: Meshing parameters plotted against the simulation run time

A.4 a_trol02

Figure A.13: Highest quality mesh with each element colored by scaled Jacobian

a_trol02: Ideal Parameters	
Minimum Mesh Quality	0.19
Smoothing Iterations	12
Laplace Iterations	4
Optimization Iterations	8
Optimization Threshold	0.50
Autosize Value	1.90
Number of Combinations Tested	840

Figure A.14: a_trol02: Meshing parameters plotted against the minimum scaled Jacobian mesh quality for each case

a_trol02: Number of Poor Quality Elements with Smoothing Iterations

a_trol02: Number of Poor Quality Elements with Optimization Iterations

a_trol02: Number of Poor Quality Elements with Laplace Iterations

a_trol02: Number of Poor Quality Elements with Optimization Threshold

Figure A.15: a_trol02: Meshing parameters plotted against the number of bad quality elements. Here, a bad quality element is defined as any element with a negative scaled Jacobian

Figure A.16: a_trol02: Meshing parameters plotted against the simulation run time

A.5 anc101

Figure A.17: Highest quality mesh with each element colored by scaled Jacobian

anc101: Ideal Parameters	
Minimum Mesh Quality	0.21
Smoothing Iterations	9
Laplace Iterations	3
Optimization Iterations	6
Optimization Threshold	0.50
Autosize Value	0.05
Number of Combinations Tested	840

Figure A.18: anc101: Meshing parameters plotted against the minimum scaled Jacobian mesh quality for each case

anc101: Number of Poor Quality Elements with Smoothing Iterations

anc101: Number of Poor Quality Elements with Optimization Iterations

anc101: Number of Poor Quality Elements with Laplace Iterations

anc101: Number of Poor Quality Elements with Optimization Threshold

Figure A.19: anc101: Meshing parameters plotted against the number of bad quality elements. Here, a bad quality element is defined as any element with a negative scaled Jacobian

Figure A.20: anc101: Meshing parameters plotted against the simulation run time

A.6 andy_hilbert

Figure A.21: Highest quality mesh with each element colored by scaled Jacobian

andy_hilbert: Ideal Parameters	
Minimum Mesh Quality	0.22
Smoothing Iterations	6
Laplace Iterations	2
Optimization Iterations	4
Optimization Threshold	0.40
Autosize Value	0.90
Number of Combinations Tested	840

Figure A.22: andy_hilbert: Meshing parameters plotted against the minimum scaled Jacobian mesh quality for each case

andy_hilbert: Number of Poor Quality Elements with Smoothing Iteration

andy_hilbert: Number of Poor Quality Elements with Optimization Iteration

andy_hilbert: Number of Poor Quality Elements with Laplace Iterations

andy_hilbert: Number of Poor Quality Elements with Optimization Threshold

Figure A.23: andy_hilbert: Meshing parameters plotted against the number of bad quality elements. Here, a bad quality element is defined as any element with a negative scaled Jacobian

Figure A.24: andy_hilbert: Meshing parameters plotted against the simulation run time

A.7 bbl1

Figure A.25: Highest quality mesh with each element colored by scaled Jacobian

bbl1: Ideal Parameters	
Minimum Mesh Quality	0.14
Smoothing Iterations	7
Laplace Iterations	1
Optimization Iterations	6
Optimization Threshold	0.40
Autosize Value	0.45
Number of Combinations Tested	840

Figure A.26: bbl1: Meshing parameters plotted against the minimum scaled Jacobian mesh quality for each case

bbl1: Number of Poor Quality Elements with Smoothing Iterations

bbl1: Number of Poor Quality Elements with Optimization Iterations

bbl1: Number of Poor Quality Elements with Laplace Iterations

bbl1: Number of Poor Quality Elements with Optimization Threshold

Figure A.27: bbl1: Meshing parameters plotted against the number of bad quality elements. Here, a bad quality element is defined as any element with a negative scaled Jacobian

Figure A.28: bbl1: Meshing parameters plotted against the simulation run time

A.8 body

Figure A.29: Highest quality mesh with each element colored by scaled Jacobian

body: Ideal Parameters	
Minimum Mesh Quality	0.17
Smoothing Iterations	9
Laplace Iterations	2
Optimization Iterations	7
Optimization Threshold	0.40
Autosize Value	1.10
Number of Combinations Tested	840

Figure A.30: body: Meshing parameters plotted against the minimum scaled Jacobian mesh quality for each case

body: Number of Poor Quality Elements with Smoothing Iterations

body: Number of Poor Quality Elements with Optimization Iterations

body: Number of Poor Quality Elements with Laplace Iterations

body: Number of Poor Quality Elements with Optimization Threshold

Figure A.31: body: Meshing parameters plotted against the number of bad quality elements. Here, a bad quality element is defined as any element with a negative scaled Jacobian

Figure A.32: body: Meshing parameters plotted against the simulation run time

A.9 bolzen

Figure A.33: Highest quality mesh with each element colored by scaled Jacobian

bolzen: Ideal Parameters	
Minimum Mesh Quality	0.57
Smoothing Iterations	8
Laplace Iterations	4
Optimization Iterations	4
Optimization Threshold	0.40
Autosize Value	1.55
Number of Combinations Tested	840

Figure A.34: bolzen: Meshing parameters plotted against the minimum scaled Jacobian mesh quality for each case

bolzen: Number of Poor Quality Elements with Smoothing Iterations

bolzen: Number of Poor Quality Elements with Optimization Iterations

bolzen: Number of Poor Quality Elements with Laplace Iterations

bolzen: Number of Poor Quality Elements with Optimization Threshold

Figure A.35: bolzen: Meshing parameters plotted against the number of bad quality elements. Here, a bad quality element is defined as any element with a negative scaled Jacobian

Figure A.36: bolzen: Meshing parameters plotted against the simulation run time

A.10 browell1

Figure A.37: Highest quality mesh with each element colored by scaled Jacobian

browell1: Ideal Parameters	
Minimum Mesh Quality	0.46
Smoothing Iterations	10
Laplace Iterations	4
Optimization Iterations	6
Optimization Threshold	0.45
Autosize Value	1.45
Number of Combinations Tested	840

Figure A.38: browell1: Meshing parameters plotted against the minimum scaled Jacobian mesh quality for each case

browell1: Number of Poor Quality Elements with Smoothing Iterations

browell1: Number of Poor Quality Elements with Optimization Iterations

browell1: Number of Poor Quality Elements with Laplace Iterations

browell1: Number of Poor Quality Elements with Optimization Threshold

Figure A.39: browell1: Meshing parameters plotted against the number of bad quality elements. Here, a bad quality element is defined as any element with a negative scaled Jacobian

Figure A.40: browell1: Meshing parameters plotted against the simulation run time

A.11 cad6

Figure A.41: Highest quality mesh with each element colored by scaled Jacobian

cad6: Ideal Parameters	
Minimum Mesh Quality	0.23
Smoothing Iterations	12
Laplace Iterations	4
Optimization Iterations	8
Optimization Threshold	0.50
Autosize Value	0.20
Number of Combinations Tested	840

Figure A.42: cad6: Meshing parameters plotted against the minimum scaled Jacobian mesh quality for each case

cad6: Number of Poor Quality Elements with Smoothing Iterations

cad6: Number of Poor Quality Elements with Optimization Iterations

cad6: Number of Poor Quality Elements with Laplace Iterations

cad6: Number of Poor Quality Elements with Optimization Threshold

Figure A.43: cad6: Meshing parameters plotted against the number of bad quality elements. Here, a bad quality element is defined as any element with a negative scaled Jacobian

Figure A.44: cad6: Meshing parameters plotted against the simulation run time

A.12 cam

Figure A.45: Highest quality mesh with each element colored by scaled Jacobian

cam: Ideal Parameters	
Minimum Mesh Quality	0.20
Smoothing Iterations	6
Laplace Iterations	2
Optimization Iterations	4
Optimization Threshold	0.50
Autosize Value	2.00
Number of Combinations Tested	840

Figure A.46: cam: Meshing parameters plotted against the minimum scaled Jacobian mesh quality for each case

cam: Number of Poor Quality Elements with Smoothing Iterations

cam: Number of Poor Quality Elements with Optimization Iterations

cam: Number of Poor Quality Elements with Laplace Iterations

cam: Number of Poor Quality Elements with Optimization Threshold

Figure A.47: cam: Meshing parameters plotted against the number of bad quality elements. Here, a bad quality element is defined as any element with a negative scaled Jacobian

Figure A.48: cam: Meshing parameters plotted against the simulation run time

A.13 chainr5

Figure A.49: Highest quality mesh with each element colored by scaled Jacobian

chainr5: Ideal Parameters	
Minimum Mesh Quality	0.28
Smoothing Iterations	8
Laplace Iterations	2
Optimization Iterations	6
Optimization Threshold	0.40
Autosize Value	1.50
Number of Combinations Tested	840

Figure A.50: chainr5: Meshing parameters plotted against the minimum scaled Jacobian mesh quality for each case

chainr5: Number of Poor Quality Elements with Smoothing Iterations

chainr5: Number of Poor Quality Elements with Optimization Iterations

chainr5: Number of Poor Quality Elements with Laplace Iterations

chainr5: Number of Poor Quality Elements with Optimization Threshold

Figure A.51: chainr5: Meshing parameters plotted against the number of bad quality elements. Here, a bad quality element is defined as any element with a negative scaled Jacobian

Figure A.52: chainr5: Meshing parameters plotted against the simulation run time

A.14 cognit

Figure A.53: Highest quality mesh with each element colored by scaled Jacobian

cognit: Ideal Parameters	
Minimum Mesh Quality	0.14
Smoothing Iterations	9
Laplace Iterations	3
Optimization Iterations	6
Optimization Threshold	0.40
Autosize Value	1.55
Number of Combinations Tested	840

Figure A.54: cognit: Meshing parameters plotted against the minimum scaled Jacobian mesh quality for each case

cognit: Number of Poor Quality Elements with Smoothing Iterations

cognit: Number of Poor Quality Elements with Optimization Iterations

cognit: Number of Poor Quality Elements with Laplace Iterations

cognit: Number of Poor Quality Elements with Optimization Threshold

Figure A.55: cognit: Meshing parameters plotted against the number of bad quality elements. Here, a bad quality element is defined as any element with a negative scaled Jacobian

Figure A.56: cognit: Meshing parameters plotted against the simulation run time

A.15 cone

Figure A.57: Highest quality mesh with each element colored by scaled Jacobian

cone: Ideal Parameters	
Minimum Mesh Quality	0.36
Smoothing Iterations	8
Laplace Iterations	3
Optimization Iterations	5
Optimization Threshold	0.40
Autosize Value	0.55
Number of Combinations Tested	840

Figure A.58: cone: Meshing parameters plotted against the minimum scaled Jacobian mesh quality for each case

cone: Number of Poor Quality Elements with Smoothing Iterations

cone: Number of Poor Quality Elements with Optimization Iterations

cone: Number of Poor Quality Elements with Laplace Iterations

cone: Number of Poor Quality Elements with Optimization Threshold

Figure A.59: cone: Meshing parameters plotted against the number of bad quality elements. Here, a bad quality element is defined as any element with a negative scaled Jacobian

Figure A.60: cone: Meshing parameters plotted against the simulation run time

A.16 coneorig

Figure A.61: Highest quality mesh with each element colored by scaled Jacobian

coneorig: Ideal Parameters	
Minimum Mesh Quality	0.35
Smoothing Iterations	9
Laplace Iterations	4
Optimization Iterations	5
Optimization Threshold	0.45
Autosize Value	1.60
Number of Combinations Tested	840

Figure A.62: coneorig: Meshing parameters plotted against the minimum scaled Jacobian mesh quality for each case

coneorig: Number of Poor Quality Elements with Smoothing Iterations

coneorig: Number of Poor Quality Elements with Optimization Iterations

coneorig: Number of Poor Quality Elements with Laplace Iterations

coneorig: Number of Poor Quality Elements with Optimization Threshold

Figure A.63: coneorig: Meshing parameters plotted against the number of bad quality elements. Here, a bad quality element is defined as any element with a negative scaled Jacobian

Figure A.64: coneorig: Meshing parameters plotted against the simulation run time

A.17 cover

Figure A.65: Highest quality mesh with each element colored by scaled Jacobian

cover: Ideal Parameters	
Minimum Mesh Quality	-0.07
Smoothing Iterations	7
Laplace Iterations	2
Optimization Iterations	5
Optimization Threshold	0.40
Autosize Value	0.85
Number of Combinations Tested	840

Figure A.66: cover: Meshing parameters plotted against the minimum scaled Jacobian mesh quality for each case

cover: Number of Poor Quality Elements with Smoothing Iterations

cover: Number of Poor Quality Elements with Optimization Iterations

cover: Number of Poor Quality Elements with Laplace Iterations

cover: Number of Poor Quality Elements with Optimization Threshold

Figure A.67: cover: Meshing parameters plotted against the number of bad quality elements. Here, a bad quality element is defined as any element with a negative scaled Jacobian

Figure A.68: cover: Meshing parameters plotted against the simulation run time

A.18 crankr3

Figure A.69: Highest quality mesh with each element colored by scaled Jacobian

crankr3: Ideal Parameters	
Minimum Mesh Quality	0.23
Smoothing Iterations	10
Laplace Iterations	4
Optimization Iterations	6
Optimization Threshold	0.45
Autosize Value	1.65
Number of Combinations Tested	840

Figure A.70: crankr3: Meshing parameters plotted against the minimum scaled Jacobian mesh quality for each case

crankr3: Number of Poor Quality Elements with Smoothing Iterations

crankr3: Number of Poor Quality Elements with Optimization Iterations

crankr3: Number of Poor Quality Elements with Laplace Iterations

crankr3: Number of Poor Quality Elements with Optimization Threshold

Figure A.71: crankr3: Meshing parameters plotted against the number of bad quality elements. Here, a bad quality element is defined as any element with a negative scaled Jacobian

Figure A.72: `crankr3`: Meshing parameters plotted against the simulation run time

A.19 ctube

Figure A.73: Highest quality mesh with each element colored by scaled Jacobian

ctube: Ideal Parameters	
Minimum Mesh Quality	0.21
Smoothing Iterations	11
Laplace Iterations	2
Optimization Iterations	9
Optimization Threshold	0.50
Autosize Value	0.95
Number of Combinations Tested	840

Figure A.74: ctube: Meshing parameters plotted against the minimum scaled Jacobian mesh quality for each case

ctube: Number of Poor Quality Elements with Smoothing Iterations

ctube: Number of Poor Quality Elements with Optimization Iterations

ctube: Number of Poor Quality Elements with Laplace Iterations

ctube: Number of Poor Quality Elements with Optimization Threshold

Figure A.75: ctube: Meshing parameters plotted against the number of bad quality elements. Here, a bad quality element is defined as any element with a negative scaled Jacobian

Figure A.76: ctube: Meshing parameters plotted against the simulation run time

A.20 cylinder

Figure A.77: Highest quality mesh with each element colored by scaled Jacobian

cylinder: Ideal Parameters	
Minimum Mesh Quality	0.39
Smoothing Iterations	6
Laplace Iterations	1
Optimization Iterations	5
Optimization Threshold	0.45
Autosize Value	0.80
Number of Combinations Tested	840

Figure A.78: cylinder: Meshing parameters plotted against the minimum scaled Jacobian mesh quality for each case

cylinder: Number of Poor Quality Elements with Smoothing Iterations

cylinder: Number of Poor Quality Elements with Optimization Iterations

cylinder: Number of Poor Quality Elements with Laplace Iterations

cylinder: Number of Poor Quality Elements with Optimization Threshold

Figure A.79: cylinder: Meshing parameters plotted against the number of bad quality elements. Here, a bad quality element is defined as any element with a negative scaled Jacobian

Figure A.80: cylinder: Meshing parameters plotted against the simulation run time

A.21 demo05

Figure A.81: Highest quality mesh with each element colored by scaled Jacobian

demo05: Ideal Parameters	
Minimum Mesh Quality	0.26
Smoothing Iterations	9
Laplace Iterations	0
Optimization Iterations	9
Optimization Threshold	0.50
Autosize Value	1.80
Number of Combinations Tested	840

Figure A.82: demo05: Meshing parameters plotted against the minimum scaled Jacobian mesh quality for each case

demo05: Number of Poor Quality Elements with Smoothing Iterations

demo05: Number of Poor Quality Elements with Optimization Iterations

demo05: Number of Poor Quality Elements with Laplace Iterations

demo05: Number of Poor Quality Elements with Optimization Threshold

Figure A.83: demo05: Meshing parameters plotted against the number of bad quality elements. Here, a bad quality element is defined as any element with a negative scaled Jacobian

Figure A.84: demo05: Meshing parameters plotted against the simulation run time

A.22 disk

Figure A.85: Highest quality mesh with each element colored by scaled Jacobian

disk: Ideal Parameters	
Minimum Mesh Quality	0.23
Smoothing Iterations	7
Laplace Iterations	1
Optimization Iterations	6
Optimization Threshold	0.50
Autosize Value	1.50
Number of Combinations Tested	840

Figure A.86: disk: Meshing parameters plotted against the minimum scaled Jacobian mesh quality for each case

disk: Number of Poor Quality Elements with Smoothing Iterations

disk: Number of Poor Quality Elements with Optimization Iterations

disk: Number of Poor Quality Elements with Laplace Iterations

disk: Number of Poor Quality Elements with Optimization Threshold

Figure A.87: disk: Meshing parameters plotted against the number of bad quality elements. Here, a bad quality element is defined as any element with a negative scaled Jacobian

Figure A.88: disk: Meshing parameters plotted against the simulation run time

A.23 displacedblock-01

Figure A.89: Highest quality mesh with each element colored by scaled Jacobian

displacedblock-01: Ideal Parameters	
Minimum Mesh Quality	0.50
Smoothing Iterations	8
Laplace Iterations	4
Optimization Iterations	4
Optimization Threshold	0.45
Autosize Value	1.50
Number of Combinations Tested	840

Figure A.90: displacedblock-01: Meshing parameters plotted against the minimum scaled Jacobian mesh quality for each case

splacelblock-01: Number of Poor Quality Elements with Smoothing Iterations

placelblock-01: Number of Poor Quality Elements with Optimization Iterations

displacelblock-01: Number of Poor Quality Elements with Laplace Iterations

placelblock-01: Number of Poor Quality Elements with Optimization Threshold

Figure A.91: displacelblock-01: Meshing parameters plotted against the number of bad quality elements. Here, a bad quality element is defined as any element with a negative scaled Jacobian

Figure A.92: displacedblock-01: Meshing parameters plotted against the simulation run time

A.24 driver

Figure A.93: Highest quality mesh with each element colored by scaled Jacobian

driver: Ideal Parameters	
Minimum Mesh Quality	0.15
Smoothing Iterations	11
Laplace Iterations	3
Optimization Iterations	8
Optimization Threshold	0.40
Autosize Value	1.50
Number of Combinations Tested	840

Figure A.94: driver: Meshing parameters plotted against the minimum scaled Jacobian mesh quality for each case

driver: Number of Poor Quality Elements with Smoothing Iterations

driver: Number of Poor Quality Elements with Optimization Iterations

driver: Number of Poor Quality Elements with Laplace Iterations

driver: Number of Poor Quality Elements with Optimization Threshold

Figure A.95: driver: Meshing parameters plotted against the number of bad quality elements. Here, a bad quality element is defined as any element with a negative scaled Jacobian

Figure A.96: driver: Meshing parameters plotted against the simulation run time

A.25 engine2

Figure A.97: Highest quality mesh with each element colored by scaled Jacobian

engine2: Ideal Parameters	
Minimum Mesh Quality	0.17
Smoothing Iterations	10
Laplace Iterations	2
Optimization Iterations	8
Optimization Threshold	0.40
Autosize Value	1.20
Number of Combinations Tested	840

Figure A.98: engine2: Meshing parameters plotted against the minimum scaled Jacobian mesh quality for each case

engine2: Number of Poor Quality Elements with Smoothing Iterations

engine2: Number of Poor Quality Elements with Optimization Iterations

engine2: Number of Poor Quality Elements with Laplace Iterations

engine2: Number of Poor Quality Elements with Optimization Threshold

Figure A.99: engine2: Meshing parameters plotted against the number of bad quality elements. Here, a bad quality element is defined as any element with a negative scaled Jacobian

Figure A.100: engine2: Meshing parameters plotted against the simulation run time

A.26 explorer_part

Figure A.101: Highest quality mesh with each element colored by scaled Jacobian

explorer_part: Ideal Parameters	
Minimum Mesh Quality	0.30
Smoothing Iterations	11
Laplace Iterations	4
Optimization Iterations	7
Optimization Threshold	0.45
Autosize Value	1.30
Number of Combinations Tested	840

Figure A.102: explorer_part: Meshing parameters plotted against the minimum scaled Jacobian mesh quality for each case

explorer_part: Number of Poor Quality Elements with Smoothing Iteration

explorer_part: Number of Poor Quality Elements with Optimization Iteratic

explorer_part: Number of Poor Quality Elements with Laplace Iterations

explorer_part: Number of Poor Quality Elements with Optimization Thresh

Figure A.103: explorer_part: Meshing parameters plotted against the number of bad quality elements. Here, a bad quality element is defined as any element with a negative scaled Jacobian

Figure A.104: explorer_part: Meshing parameters plotted against the simulation run time

A.27 fender_done

Figure A.105: Highest quality mesh with each element colored by scaled Jacobian

fender_done: Ideal Parameters	
Minimum Mesh Quality	0.18
Smoothing Iterations	9
Laplace Iterations	0
Optimization Iterations	9
Optimization Threshold	0.40
Autosize Value	0.55
Number of Combinations Tested	840

Figure A.106: fender_done: Meshing parameters plotted against the minimum scaled Jacobian mesh quality for each case

fender_done: Number of Poor Quality Elements with Smoothing Iteration

fender_done: Number of Poor Quality Elements with Optimization Iteration

fender_done: Number of Poor Quality Elements with Laplace Iterations

fender_done: Number of Poor Quality Elements with Optimization Threshold

Figure A.107: fender_done: Meshing parameters plotted against the number of bad quality elements. Here, a bad quality element is defined as any element with a negative scaled Jacobian

Figure A.108: fender_done: Meshing parameters plotted against the simulation run time

A.28 funnel

Figure A.109: Highest quality mesh with each element colored by scaled Jacobian

funnel: Ideal Parameters	
Minimum Mesh Quality	0.19
Smoothing Iterations	9
Laplace Iterations	4
Optimization Iterations	5
Optimization Threshold	0.40
Autosize Value	1.05
Number of Combinations Tested	840

Figure A.110: funnel: Meshing parameters plotted against the minimum scaled Jacobian mesh quality for each case

funnel: Number of Poor Quality Elements with Smoothing Iterations

funnel: Number of Poor Quality Elements with Optimization Iterations

funnel: Number of Poor Quality Elements with Laplace Iterations

funnel: Number of Poor Quality Elements with Optimization Threshold

Figure A.111: funnel: Meshing parameters plotted against the number of bad quality elements. Here, a bad quality element is defined as any element with a negative scaled Jacobian

Figure A.112: funnel: Meshing parameters plotted against the simulation run time

A.29 goose16

Figure A.113: Highest quality mesh with each element colored by scaled Jacobian

goose16: Ideal Parameters	
Minimum Mesh Quality	0.26
Smoothing Iterations	7
Laplace Iterations	1
Optimization Iterations	6
Optimization Threshold	0.50
Autosize Value	1.80
Number of Combinations Tested	840

Figure A.114: goose16: Meshing parameters plotted against the minimum scaled Jacobian mesh quality for each case

goose16: Number of Poor Quality Elements with Smoothing Iterations

goose16: Number of Poor Quality Elements with Optimization Iterations

goose16: Number of Poor Quality Elements with Laplace Iterations

goose16: Number of Poor Quality Elements with Optimization Threshold

Figure A.115: goose16: Meshing parameters plotted against the number of bad quality elements. Here, a bad quality element is defined as any element with a negative scaled Jacobian

Figure A.116: goose16: Meshing parameters plotted against the simulation run time

A.30 handlex2

Figure A.117: Highest quality mesh with each element colored by scaled Jacobian

handlex2: Ideal Parameters	
Minimum Mesh Quality	0.27
Smoothing Iterations	9
Laplace Iterations	1
Optimization Iterations	8
Optimization Threshold	0.45
Autosize Value	0.65
Number of Combinations Tested	840

Figure A.118: handlex2: Meshing parameters plotted against the minimum scaled Jacobian mesh quality for each case

handlex2: Number of Poor Quality Elements with Smoothing Iterations

handlex2: Number of Poor Quality Elements with Optimization Iterations

handlex2: Number of Poor Quality Elements with Laplace Iterations

handlex2: Number of Poor Quality Elements with Optimization Threshold

Figure A.119: handlex2: Meshing parameters plotted against the number of bad quality elements. Here, a bad quality element is defined as any element with a negative scaled Jacobian

Figure A.120: handlex2: Meshing parameters plotted against the simulation run time

A.31 keg_ds

Figure A.121: Highest quality mesh with each element colored by scaled Jacobian

keg_ds: Ideal Parameters	
Minimum Mesh Quality	0.38
Smoothing Iterations	9
Laplace Iterations	4
Optimization Iterations	5
Optimization Threshold	0.50
Autosize Value	1.20
Number of Combinations Tested	840

Figure A.122: keg_ds: Meshing parameters plotted against the minimum scaled Jacobian mesh quality for each case

keg_ds: Number of Poor Quality Elements with Smoothing Iterations

keg_ds: Number of Poor Quality Elements with Optimization Iterations

keg_ds: Number of Poor Quality Elements with Laplace Iterations

keg_ds: Number of Poor Quality Elements with Optimization Threshold

Figure A.123: keg_ds: Meshing parameters plotted against the number of bad quality elements. Here, a bad quality element is defined as any element with a negative scaled Jacobian

Figure A.124: keg_ds: Meshing parameters plotted against the simulation run time

A.32 λ

Figure A.125: Highest quality mesh with each element colored by scaled Jacobian

lamb: Ideal Parameters	
Minimum Mesh Quality	-0.87
Smoothing Iterations	10
Laplace Iterations	0
Optimization Iterations	10
Optimization Threshold	0.40
Autosize Value	0.75
Number of Combinations Tested	840

Figure A.126: lamb: Meshing parameters plotted against the minimum scaled Jacobian mesh quality for each case

lamb: Number of Poor Quality Elements with Smoothing Iterations

lamb: Number of Poor Quality Elements with Optimization Iterations

lamb: Number of Poor Quality Elements with Laplace Iterations

lamb: Number of Poor Quality Elements with Optimization Threshold

Figure A.127: lamb: Meshing parameters plotted against the number of bad quality elements. Here, a bad quality element is defined as any element with a negative scaled Jacobian

Figure A.128: lamb: Meshing parameters plotted against the simulation run time

A.33 lever_part

Figure A.129: Highest quality mesh with each element colored by scaled Jacobian

lever_part: Ideal Parameters	
Minimum Mesh Quality	0.35
Smoothing Iterations	9
Laplace Iterations	4
Optimization Iterations	5
Optimization Threshold	0.50
Autosize Value	0.20
Number of Combinations Tested	840

Figure A.130: lever_part: Meshing parameters plotted against the minimum scaled Jacobian mesh quality for each case

lever_part: Number of Poor Quality Elements with Smoothing Iterations

lever_part: Number of Poor Quality Elements with Optimization Iteration

lever_part: Number of Poor Quality Elements with Laplace Iterations

lever_part: Number of Poor Quality Elements with Optimization Threshold

Figure A.131: lever_part: Meshing parameters plotted against the number of bad quality elements. Here, a bad quality element is defined as any element with a negative scaled Jacobian

Figure A.132: lever_part: Meshing parameters plotted against the simulation run time

A.34 lt-vhs

Figure A.133: Highest quality mesh with each element colored by scaled Jacobian

It-vhs: Ideal Parameters	
Minimum Mesh Quality	0.18
Smoothing Iterations	10
Laplace Iterations	0
Optimization Iterations	10
Optimization Threshold	0.45
Autosize Value	1.30
Number of Combinations Tested	840

Figure A.134: It-vhs: Meshing parameters plotted against the minimum scaled Jacobian mesh quality for each case

It-vhs: Number of Poor Quality Elements with Smoothing Iterations

It-vhs: Number of Poor Quality Elements with Optimization Iterations

It-vhs: Number of Poor Quality Elements with Laplace Iterations

It-vhs: Number of Poor Quality Elements with Optimization Threshold

Figure A.135: It-vhs: Meshing parameters plotted against the number of bad quality elements. Here, a bad quality element is defined as any element with a negative scaled Jacobian

Figure A.136: It-vhs: Meshing parameters plotted against the simulation run time

A.35 m51

Figure A.137: Highest quality mesh with each element colored by scaled Jacobian

m51: Ideal Parameters	
Minimum Mesh Quality	0.18
Smoothing Iterations	12
Laplace Iterations	2
Optimization Iterations	10
Optimization Threshold	0.40
Autosize Value	1.65
Number of Combinations Tested	840

Figure A.138: m51: Meshing parameters plotted against the minimum scaled Jacobian mesh quality for each case

m51: Number of Poor Quality Elements with Smoothing Iterations

m51: Number of Poor Quality Elements with Optimization Iterations

m51: Number of Poor Quality Elements with Laplace Iterations

m51: Number of Poor Quality Elements with Optimization Threshold

Figure A.139: m51: Meshing parameters plotted against the number of bad quality elements. Here, a bad quality element is defined as any element with a negative scaled Jacobian

Figure A.140: m51: Meshing parameters plotted against the simulation run time

A.36 part29

Figure A.141: Highest quality mesh with each element colored by scaled Jacobian

part29: Ideal Parameters	
Minimum Mesh Quality	0.25
Smoothing Iterations	11
Laplace Iterations	4
Optimization Iterations	7
Optimization Threshold	0.50
Autosize Value	0.05
Number of Combinations Tested	840

Figure A.142: part29: Meshing parameters plotted against the minimum scaled Jacobian mesh quality for each case

part29: Number of Poor Quality Elements with Smoothing Iterations

part29: Number of Poor Quality Elements with Optimization Iterations

part29: Number of Poor Quality Elements with Laplace Iterations

part29: Number of Poor Quality Elements with Optimization Threshold

Figure A.143: part29: Meshing parameters plotted against the number of bad quality elements. Here, a bad quality element is defined as any element with a negative scaled Jacobian

Figure A.144: part29: Meshing parameters plotted against the simulation run time

A.37 plunger

Figure A.145: Highest quality mesh with each element colored by scaled Jacobian

plunger: Ideal Parameters	
Minimum Mesh Quality	0.35
Smoothing Iterations	8
Laplace Iterations	4
Optimization Iterations	4
Optimization Threshold	0.50
Autosize Value	1.50
Number of Combinations Tested	840

Figure A.146: plunger: Meshing parameters plotted against the minimum scaled Jacobian mesh quality for each case

plunger: Number of Poor Quality Elements with Smoothing Iterations

plunger: Number of Poor Quality Elements with Optimization Iterations

plunger: Number of Poor Quality Elements with Laplace Iterations

plunger: Number of Poor Quality Elements with Optimization Threshold

Figure A.147: plunger: Meshing parameters plotted against the number of bad quality elements. Here, a bad quality element is defined as any element with a negative scaled Jacobian

Figure A.148: plunger: Meshing parameters plotted against the simulation run time

A.38 pump

Figure A.149: Highest quality mesh with each element colored by scaled Jacobian

pump: Ideal Parameters	
Minimum Mesh Quality	0.11
Smoothing Iterations	11
Laplace Iterations	1
Optimization Iterations	10
Optimization Threshold	0.40
Autosize Value	1.65
Number of Combinations Tested	840

Figure A.150: pump: Meshing parameters plotted against the minimum scaled Jacobian mesh quality for each case

pump: Number of Poor Quality Elements with Smoothing Iterations

pump: Number of Poor Quality Elements with Optimization Iterations

pump: Number of Poor Quality Elements with Laplace Iterations

pump: Number of Poor Quality Elements with Optimization Threshold

Figure A.151: pump: Meshing parameters plotted against the number of bad quality elements. Here, a bad quality element is defined as any element with a negative scaled Jacobian

Figure A.152: pump: Meshing parameters plotted against the simulation run time

A.39 quartercubewhole

Figure A.153: Highest quality mesh with each element colored by scaled Jacobian

quatercubewhole: Ideal Parameters	
Minimum Mesh Quality	0.32
Smoothing Iterations	8
Laplace Iterations	3
Optimization Iterations	5
Optimization Threshold	0.50
Autosize Value	1.55
Number of Combinations Tested	840

Figure A.154: quatercubewhole: Meshing parameters plotted against the minimum scaled Jacobian mesh quality for each case

artercubewhole: Number of Poor Quality Elements with Smoothing Iterat

artercubewhole: Number of Poor Quality Elements with Optimization Itera

quatercubewhole: Number of Poor Quality Elements with Laplace Iteratic

artercubewhole: Number of Poor Quality Elements with Optimization Thre

Figure A.155: quatercubewhole: Meshing parameters plotted against the number of bad quality elements. Here, a bad quality element is defined as any element with a negative scaled Jacobian

Figure A.156: quartercubewhole: Meshing parameters plotted against the simulation run time

A.40 railsupport

Figure A.157: Highest quality mesh with each element colored by scaled Jacobian

railsupport: Ideal Parameters	
Minimum Mesh Quality	0.30
Smoothing Iterations	12
Laplace Iterations	3
Optimization Iterations	9
Optimization Threshold	0.45
Autosize Value	1.00
Number of Combinations Tested	840

Figure A.158: railsupport: Meshing parameters plotted against the minimum scaled Jacobian mesh quality for each case

railsupport: Number of Poor Quality Elements with Smoothing Iterations

railsupport: Number of Poor Quality Elements with Optimization Iteration

railsupport: Number of Poor Quality Elements with Laplace Iterations

railsupport: Number of Poor Quality Elements with Optimization Threshold

Figure A.159: railsupport: Meshing parameters plotted against the number of bad quality elements. Here, a bad quality element is defined as any element with a negative scaled Jacobian

Figure A.160: railsupport: Meshing parameters plotted against the simulation run time

A.41 rib2a

Figure A.161: Highest quality mesh with each element colored by scaled Jacobian

rib2a: Ideal Parameters	
Minimum Mesh Quality	0.30
Smoothing Iterations	12
Laplace Iterations	4
Optimization Iterations	8
Optimization Threshold	0.50
Autosize Value	1.70
Number of Combinations Tested	840

Figure A.162: rib2a: Meshing parameters plotted against the minimum scaled Jacobian mesh quality for each case

rib2a: Number of Poor Quality Elements with Smoothing Iterations

rib2a: Number of Poor Quality Elements with Optimization Iterations

rib2a: Number of Poor Quality Elements with Laplace Iterations

rib2a: Number of Poor Quality Elements with Optimization Threshold

Figure A.163: rib2a: Meshing parameters plotted against the number of bad quality elements. Here, a bad quality element is defined as any element with a negative scaled Jacobian

Figure A.164: rib2a: Meshing parameters plotted against the simulation run time

A.42 rim_done

Figure A.165: Highest quality mesh with each element colored by scaled Jacobian

rim_done: Ideal Parameters	
Minimum Mesh Quality	0.16
Smoothing Iterations	9
Laplace Iterations	2
Optimization Iterations	7
Optimization Threshold	0.50
Autosize Value	2.00
Number of Combinations Tested	840

Figure A.166: rim_done: Meshing parameters plotted against the minimum scaled Jacobian mesh quality for each case

rim_done: Number of Poor Quality Elements with Smoothing Iterations

rim_done: Number of Poor Quality Elements with Optimization Iterations

rim_done: Number of Poor Quality Elements with Laplace Iterations

rim_done: Number of Poor Quality Elements with Optimization Threshold

Figure A.167: rim_done: Meshing parameters plotted against the number of bad quality elements. Here, a bad quality element is defined as any element with a negative scaled Jacobian

Figure A.168: rim_done: Meshing parameters plotted against the simulation run time

A.43 rocker

Figure A.169: Highest quality mesh with each element colored by scaled Jacobian

rocker: Ideal Parameters	
Minimum Mesh Quality	0.14
Smoothing Iterations	12
Laplace Iterations	3
Optimization Iterations	9
Optimization Threshold	0.45
Autosize Value	1.10
Number of Combinations Tested	840

Figure A.170: rocker: Meshing parameters plotted against the minimum scaled Jacobian mesh quality for each case

rocker: Number of Poor Quality Elements with Smoothing Iterations

rocker: Number of Poor Quality Elements with Optimization Iterations

rocker: Number of Poor Quality Elements with Laplace Iterations

rocker: Number of Poor Quality Elements with Optimization Threshold

Figure A.171: rocker: Meshing parameters plotted against the number of bad quality elements. Here, a bad quality element is defined as any element with a negative scaled Jacobian

Figure A.172: rocker: Meshing parameters plotted against the simulation run time

A.44 sbase1

Figure A.173: Highest quality mesh with each element colored by scaled Jacobian

sbase1: Ideal Parameters	
Minimum Mesh Quality	0.33
Smoothing Iterations	8
Laplace Iterations	4
Optimization Iterations	4
Optimization Threshold	0.50
Autosize Value	1.45
Number of Combinations Tested	840

Figure A.174: sbase1: Meshing parameters plotted against the minimum scaled Jacobian mesh quality for each case

sbase1: Number of Poor Quality Elements with Smoothing Iterations

sbase1: Number of Poor Quality Elements with Optimization Iterations

sbase1: Number of Poor Quality Elements with Laplace Iterations

sbase1: Number of Poor Quality Elements with Optimization Threshold

Figure A.175: sbase1: Meshing parameters plotted against the number of bad quality elements. Here, a bad quality element is defined as any element with a negative scaled Jacobian

Figure A.176: sbase1: Meshing parameters plotted against the simulation run time

A.45 spdlbrk2

Figure A.177: Highest quality mesh with each element colored by scaled Jacobian

spdlbrk2: Ideal Parameters	
Minimum Mesh Quality	0.21
Smoothing Iterations	9
Laplace Iterations	1
Optimization Iterations	8
Optimization Threshold	0.50
Autosize Value	1.70
Number of Combinations Tested	840

Figure A.178: spdlbrk2: Meshing parameters plotted against the minimum scaled Jacobian mesh quality for each case

spdlbrk2: Number of Poor Quality Elements with Smoothing Iterations

spdlbrk2: Number of Poor Quality Elements with Optimization Iterations

spdlbrk2: Number of Poor Quality Elements with Laplace Iterations

spdlbrk2: Number of Poor Quality Elements with Optimization Threshold

Figure A.179: spdlbrk2: Meshing parameters plotted against the number of bad quality elements. Here, a bad quality element is defined as any element with a negative scaled Jacobian

Figure A.180: spdbrk2: Meshing parameters plotted against the simulation run time

A.46 sphere

Figure A.181: Highest quality mesh with each element colored by scaled Jacobian

sphere: Ideal Parameters	
Minimum Mesh Quality	0.35
Smoothing Iterations	9
Laplace Iterations	4
Optimization Iterations	5
Optimization Threshold	0.50
Autosize Value	1.70
Number of Combinations Tested	840

Figure A.182: sphere: Meshing parameters plotted against the minimum scaled Jacobian mesh quality for each case

sphere: Number of Poor Quality Elements with Smoothing Iterations

sphere: Number of Poor Quality Elements with Optimization Iterations

sphere: Number of Poor Quality Elements with Laplace Iterations

sphere: Number of Poor Quality Elements with Optimization Threshold

Figure A.183: sphere: Meshing parameters plotted against the number of bad quality elements. Here, a bad quality element is defined as any element with a negative scaled Jacobian

Figure A.184: sphere: Meshing parameters plotted against the simulation run time

A.47 spindle4

Figure A.185: Highest quality mesh with each element colored by scaled Jacobian

spindle4: Ideal Parameters	
Minimum Mesh Quality	0.31
Smoothing Iterations	10
Laplace Iterations	1
Optimization Iterations	9
Optimization Threshold	0.50
Autosize Value	1.15
Number of Combinations Tested	840

Figure A.186: spindle4: Meshing parameters plotted against the minimum scaled Jacobian mesh quality for each case

spindle4: Number of Poor Quality Elements with Smoothing Iterations

spindle4: Number of Poor Quality Elements with Optimization Iterations

spindle4: Number of Poor Quality Elements with Laplace Iterations

spindle4: Number of Poor Quality Elements with Optimization Threshold

Figure A.187: spindle4: Meshing parameters plotted against the number of bad quality elements. Here, a bad quality element is defined as any element with a negative scaled Jacobian

Figure A.188: spindle4: Meshing parameters plotted against the simulation run time

A.48 sprayer

Figure A.189: Highest quality mesh with each element colored by scaled Jacobian

sprayer: Ideal Parameters	
Minimum Mesh Quality	0.35
Smoothing Iterations	13
Laplace Iterations	4
Optimization Iterations	9
Optimization Threshold	0.50
Autosize Value	1.00
Number of Combinations Tested	840

Figure A.190: sprayer: Meshing parameters plotted against the minimum scaled Jacobian mesh quality for each case

sprayer: Number of Poor Quality Elements with Smoothing Iterations

sprayer: Number of Poor Quality Elements with Optimization Iterations

sprayer: Number of Poor Quality Elements with Laplace Iterations

sprayer: Number of Poor Quality Elements with Optimization Threshold

Figure A.191: sprayer: Meshing parameters plotted against the number of bad quality elements. Here, a bad quality element is defined as any element with a negative scaled Jacobian

Figure A.192: sprayer: Meshing parameters plotted against the simulation run time

A.49 std_3ax

Figure A.193: Highest quality mesh with each element colored by scaled Jacobian

std_3ax: Ideal Parameters	
Minimum Mesh Quality	0.23
Smoothing Iterations	9
Laplace Iterations	4
Optimization Iterations	5
Optimization Threshold	0.45
Autosize Value	1.65
Number of Combinations Tested	840

Figure A.194: std_3ax: Meshing parameters plotted against the minimum scaled Jacobian mesh quality for each case

std_3ax: Number of Poor Quality Elements with Smoothing Iterations

std_3ax: Number of Poor Quality Elements with Optimization Iterations

std_3ax: Number of Poor Quality Elements with Laplace Iterations

std_3ax: Number of Poor Quality Elements with Optimization Threshold

Figure A.195: std_3ax: Meshing parameters plotted against the number of bad quality elements. Here, a bad quality element is defined as any element with a negative scaled Jacobian

Figure A.196: std_3ax: Meshing parameters plotted against the simulation run time

A.50 test_1

Figure A.197: Highest quality mesh with each element colored by scaled Jacobian

test_1: Ideal Parameters	
Minimum Mesh Quality	0.01
Smoothing Iterations	12
Laplace Iterations	3
Optimization Iterations	9
Optimization Threshold	0.40
Autosize Value	1.75
Number of Combinations Tested	840

Figure A.198: test_1: Meshing parameters plotted against the minimum scaled Jacobian mesh quality for each case

test_1: Number of Poor Quality Elements with Smoothing Iterations

test_1: Number of Poor Quality Elements with Optimization Iterations

test_1: Number of Poor Quality Elements with Laplace Iterations

test_1: Number of Poor Quality Elements with Optimization Threshold

Figure A.199: test_1: Meshing parameters plotted against the number of bad quality elements. Here, a bad quality element is defined as any element with a negative scaled Jacobian

Figure A.200: test_1: Meshing parameters plotted against the simulation run time

A.51 trane

Figure A.201: Highest quality mesh with each element colored by scaled Jacobian

trane: Ideal Parameters	
Minimum Mesh Quality	0.16
Smoothing Iterations	8
Laplace Iterations	2
Optimization Iterations	6
Optimization Threshold	0.40
Autosize Value	0.45
Number of Combinations Tested	840

Figure A.202: trane: Meshing parameters plotted against the minimum scaled Jacobian mesh quality for each case

trane: Number of Poor Quality Elements with Smoothing Iterations

trane: Number of Poor Quality Elements with Optimization Iterations

trane: Number of Poor Quality Elements with Laplace Iterations

trane: Number of Poor Quality Elements with Optimization Threshold

Figure A.203: trane: Meshing parameters plotted against the number of bad quality elements. Here, a bad quality element is defined as any element with a negative scaled Jacobian

Figure A.204: trane: Meshing parameters plotted against the simulation run time

A.52 varco2

Figure A.205: Highest quality mesh with each element colored by scaled Jacobian

varco2: Ideal Parameters	
Minimum Mesh Quality	0.35
Smoothing Iterations	14
Laplace Iterations	4
Optimization Iterations	10
Optimization Threshold	0.50
Autosize Value	1.30
Number of Combinations Tested	840

Figure A.206: varco2: Meshing parameters plotted against the minimum scaled Jacobian mesh quality for each case

varco2: Number of Poor Quality Elements with Smoothing Iterations

varco2: Number of Poor Quality Elements with Optimization Iterations

varco2: Number of Poor Quality Elements with Laplace Iterations

varco2: Number of Poor Quality Elements with Optimization Threshold

Figure A.207: varco2: Meshing parameters plotted against the number of bad quality elements. Here, a bad quality element is defined as any element with a negative scaled Jacobian

Figure A.208: varco2: Meshing parameters plotted against the simulation run time

A.53 wizard-stress_part

Figure A.209: Highest quality mesh with each element colored by scaled Jacobian

wizard-stress_part: Ideal Parameters	
Minimum Mesh Quality	0.30
Smoothing Iterations	7
Laplace Iterations	2
Optimization Iterations	5
Optimization Threshold	0.45
Autosize Value	0.50
Number of Combinations Tested	840

Figure A.210: wizard-stress_part: Meshing parameters plotted against the minimum scaled Jacobian mesh quality for each case

zard-stress_part: Number of Poor Quality Elements with Smoothing Itera

ard-stress_part: Number of Poor Quality Elements with Optimization Itera

vizard-stress_part: Number of Poor Quality Elements with Laplace Iterati

ard-stress_part: Number of Poor Quality Elements with Optimization Thre

Figure A.211: wizard-stress_part: Meshing parameters plotted against the number of bad quality elements. Here, a bad quality element is defined as any element with a negative scaled Jacobian

Figure A.212: wizard-stress_part: Meshing parameters plotted against the simulation run time

A.54 yoke_male

Figure A.213: Highest quality mesh with each element colored by scaled Jacobian

yoke_male: Ideal Parameters	
Minimum Mesh Quality	0.45
Smoothing Iterations	9
Laplace Iterations	4
Optimization Iterations	5
Optimization Threshold	0.50
Autosize Value	0.75
Number of Combinations Tested	840

Figure A.214: yoke_male: Meshing parameters plotted against the minimum scaled Jacobian mesh quality for each case

yoke_male: Number of Poor Quality Elements with Smoothing Iterations

yoke_male: Number of Poor Quality Elements with Optimization Iteration

yoke_male: Number of Poor Quality Elements with Laplace Iterations

yoke_male: Number of Poor Quality Elements with Optimization Threshold

Figure A.215: yoke_male: Meshing parameters plotted against the number of bad quality elements. Here, a bad quality element is defined as any element with a negative scaled Jacobian

Figure A.216: yoke_male: Meshing parameters plotted against the simulation run time

Appendix B

Example Run Files

B.1 a_trol02.sat

```
1 import acis '/satFiles/a_trol02.sat' attributes on separate.bodies
2
3 sculpt parallel volume all processors 1 Fileroot ...
  'a_trol02_AS1.900_Sit04_nL00_OptTH0.40_nCPU01' overwrite no_execute ...
  autosize 1.900 siterations 4 num_laplace 0 opt_threshold 0.40
4
5 sculpt parallel volume all processors 1 Fileroot ...
  'a_trol02_AS1.900_Sit05_nL01_OptTH0.40_nCPU01' overwrite no_execute ...
  autosize 1.900 siterations 5 num_laplace 1 opt_threshold 0.40
6
7 sculpt parallel volume all processors 1 Fileroot ...
  'a_trol02_AS1.900_Sit06_nL02_OptTH0.40_nCPU01' overwrite no_execute ...
  autosize 1.900 siterations 6 num_laplace 2 opt_threshold 0.40
8
9 sculpt parallel volume all processors 1 Fileroot ...
  'a_trol02_AS1.900_Sit07_nL03_OptTH0.40_nCPU01' overwrite no_execute ...
  autosize 1.900 siterations 7 num_laplace 3 opt_threshold 0.40
10
11 sculpt parallel volume all processors 1 Fileroot ...
  'a_trol02_AS1.900_Sit08_nL04_OptTH0.40_nCPU01' overwrite no_execute ...
  autosize 1.900 siterations 8 num_laplace 4 opt_threshold 0.40
12
13 sculpt parallel volume all processors 1 Fileroot ...
  'a_trol02_AS1.900_Sit05_nL00_OptTH0.40_nCPU01' overwrite no_execute ...
  autosize 1.900 siterations 5 num_laplace 0 opt_threshold 0.40
14
15 sculpt parallel volume all processors 1 Fileroot ...
  'a_trol02_AS1.900_Sit06_nL01_OptTH0.40_nCPU01' overwrite no_execute ...
  autosize 1.900 siterations 6 num_laplace 1 opt_threshold 0.40
16
17 sculpt parallel volume all processors 1 Fileroot ...
  'a_trol02_AS1.900_Sit07_nL02_OptTH0.40_nCPU01' overwrite no_execute ...
  autosize 1.900 siterations 7 num_laplace 2 opt_threshold 0.40
18
19 sculpt parallel volume all processors 1 Fileroot ...
  'a_trol02_AS1.900_Sit08_nL03_OptTH0.40_nCPU01' overwrite no_execute ...
```

```

    autosize 1.900 siterations 8 num_laplace 3 opt_threshold 0.40
20
21 sculpt parallel volume all processors 1 Fileroot ...
    'a_trol02_AS1.900_Sit09_nL04_OptTH0.40_nCPU01' overwrite no_execute ...
    autosize 1.900 siterations 9 num_laplace 4 opt_threshold 0.40
22
23 sculpt parallel volume all processors 1 Fileroot ...
    'a_trol02_AS1.900_Sit06_nL00_OptTH0.40_nCPU01' overwrite no_execute ...
    autosize 1.900 siterations 6 num_laplace 0 opt_threshold 0.40
24
25 sculpt parallel volume all processors 1 Fileroot ...
    'a_trol02_AS1.900_Sit07_nL01_OptTH0.40_nCPU01' overwrite no_execute ...
    autosize 1.900 siterations 7 num_laplace 1 opt_threshold 0.40
26
27 sculpt parallel volume all processors 1 Fileroot ...
    'a_trol02_AS1.900_Sit08_nL02_OptTH0.40_nCPU01' overwrite no_execute ...
    autosize 1.900 siterations 8 num_laplace 2 opt_threshold 0.40
28
29 reset

```

B.2 disk.sat

```

1 import acis '/satFiles/disk.sat' attributes on separate.bodies
2
3 sculpt parallel volume all processors 1 Fileroot ...
    'disk_AS1.500_Sit04_nL00_OptTH0.40_nCPU01' overwrite no_execute ...
    autosize 1.500 siterations 4 num_laplace 0 opt_threshold 0.40
4
5 sculpt parallel volume all processors 1 Fileroot ...
    'disk_AS1.500_Sit05_nL01_OptTH0.40_nCPU01' overwrite no_execute ...
    autosize 1.500 siterations 5 num_laplace 1 opt_threshold 0.40
6
7 sculpt parallel volume all processors 1 Fileroot ...
    'disk_AS1.500_Sit06_nL02_OptTH0.40_nCPU01' overwrite no_execute ...
    autosize 1.500 siterations 6 num_laplace 2 opt_threshold 0.40
8
9 sculpt parallel volume all processors 1 Fileroot ...
    'disk_AS1.500_Sit07_nL03_OptTH0.40_nCPU01' overwrite no_execute ...
    autosize 1.500 siterations 7 num_laplace 3 opt_threshold 0.40
10
11 sculpt parallel volume all processors 1 Fileroot ...
    'disk_AS1.500_Sit08_nL04_OptTH0.40_nCPU01' overwrite no_execute ...
    autosize 1.500 siterations 8 num_laplace 4 opt_threshold 0.40
12
13 sculpt parallel volume all processors 1 Fileroot ...
    'disk_AS1.500_Sit05_nL00_OptTH0.40_nCPU01' overwrite no_execute ...
    autosize 1.500 siterations 5 num_laplace 0 opt_threshold 0.40
14

```

```

15 sculpt parallel volume all processors 1 Fileroot ...
    'disk_AS1.500_Sit06_nL01_OptTH0.40_nCPU01' overwrite no_execute ...
    autosize 1.500 siterations 6 num_laplace 1 opt_threshold 0.40
16
17 sculpt parallel volume all processors 1 Fileroot ...
    'disk_AS1.500_Sit07_nL02_OptTH0.40_nCPU01' overwrite no_execute ...
    autosize 1.500 siterations 7 num_laplace 2 opt_threshold 0.40
18
19 sculpt parallel volume all processors 1 Fileroot ...
    'disk_AS1.500_Sit08_nL03_OptTH0.40_nCPU01' overwrite no_execute ...
    autosize 1.500 siterations 8 num_laplace 3 opt_threshold 0.40
20
21 sculpt parallel volume all processors 1 Fileroot ...
    'disk_AS1.500_Sit09_nL04_OptTH0.40_nCPU01' overwrite no_execute ...
    autosize 1.500 siterations 9 num_laplace 4 opt_threshold 0.40
22
23 sculpt parallel volume all processors 1 Fileroot ...
    'disk_AS1.500_Sit06_nL00_OptTH0.40_nCPU01' overwrite no_execute ...
    autosize 1.500 siterations 6 num_laplace 0 opt_threshold 0.40
24
25 sculpt parallel volume all processors 1 Fileroot ...
    'disk_AS1.500_Sit07_nL01_OptTH0.40_nCPU01' overwrite no_execute ...
    autosize 1.500 siterations 7 num_laplace 1 opt_threshold 0.40
26
27 sculpt parallel volume all processors 1 Fileroot ...
    'disk_AS1.500_Sit08_nL02_OptTH0.40_nCPU01' overwrite no_execute ...
    autosize 1.500 siterations 8 num_laplace 2 opt_threshold 0.40
28
29 sculpt parallel volume all processors 1 Fileroot ...
    'disk_AS1.500_Sit09_nL03_OptTH0.40_nCPU01' overwrite no_execute ...
    autosize 1.500 siterations 9 num_laplace 3 opt_threshold 0.40
30
31 sculpt parallel volume all processors 1 Fileroot ...
    'disk_AS1.500_Sit10_nL04_OptTH0.40_nCPU01' overwrite no_execute ...
    autosize 1.500 siterations 10 num_laplace 4 opt_threshold 0.40
32
33 sculpt parallel volume all processors 1 Fileroot ...
    'disk_AS1.500_Sit07_nL00_OptTH0.40_nCPU01' overwrite no_execute ...
    autosize 1.500 siterations 7 num_laplace 0 opt_threshold 0.40
34
35 reset

```

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