Dyson Cyclone V10

Team 4

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Presentation Outline

- Introduction
- Objectives
- Modeling
- Assembly
- FEA
- Validation of FEA

Introduction

- Dyson products are known for using bladeless fan technology, looks good, and feels good to use
- Products are high quality and go through vigorous testing
- Challenge ourselves by modeling & running stress analysis of the Dyson Cyclone V10 in detail

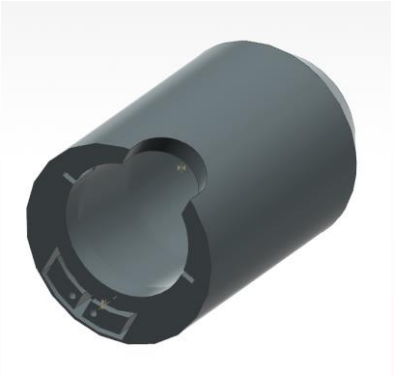
Objectives

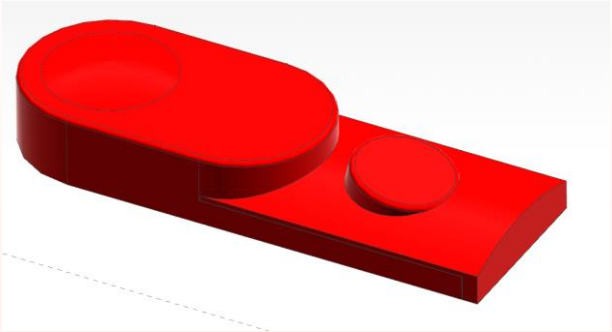
- ✓ Detailed modeling & assembly of Dyson Cyclone V10
- ✓ Perform stress analysis on:
  - Forces acting on latch
  - Bending force acting on wand
  - Forces on the cleaner head when pushing against another object
- ✓ Suggested improvements to further improve quality of Dyson products

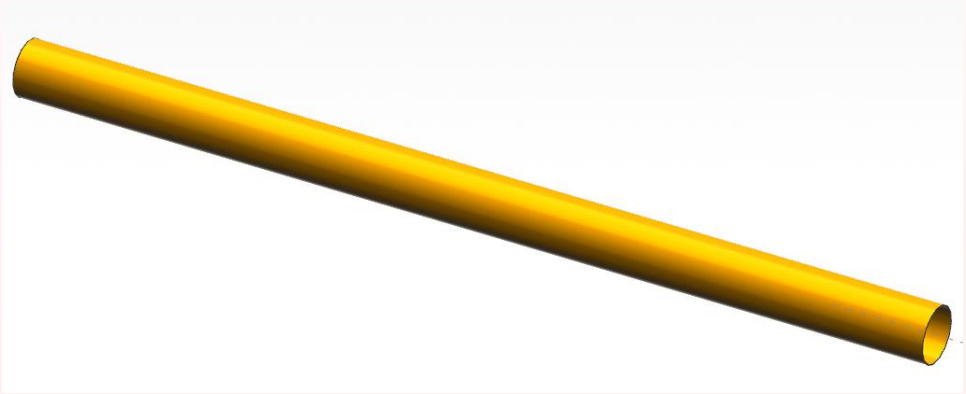
Component Modeling

- ✓ 35 different components to the model
- ✓ Modeling techniques
  - Extruded sketches, revolved sketches, angled and offset datum planes, linear and circular patterns

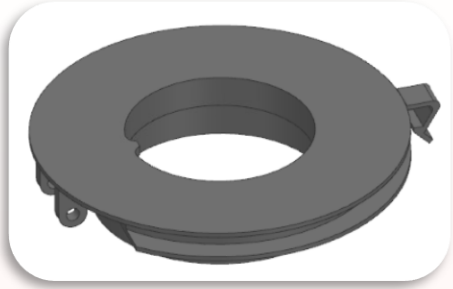
Wand Parts

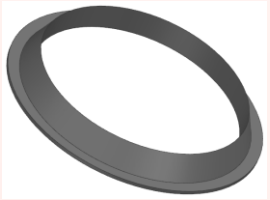


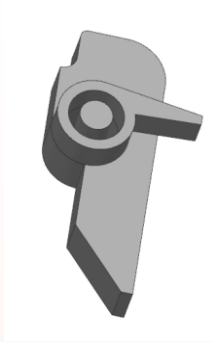




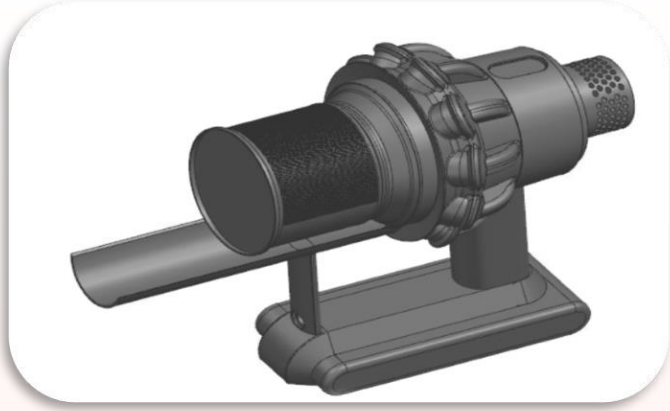
Dustbin Parts

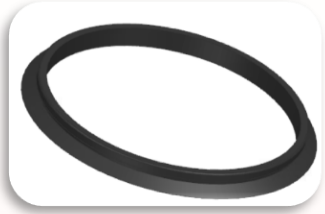


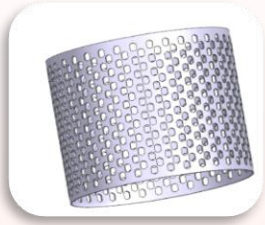




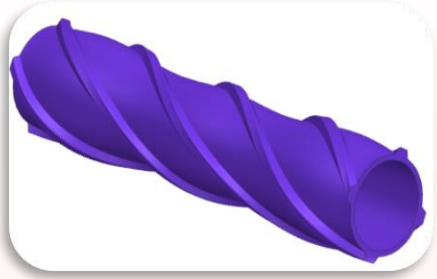
Main Body Parts

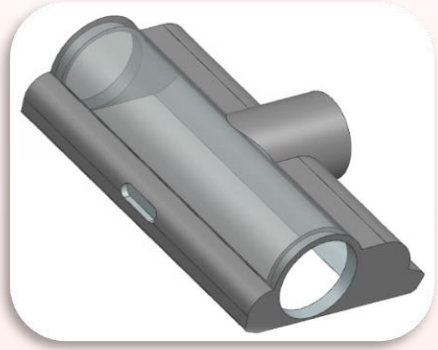


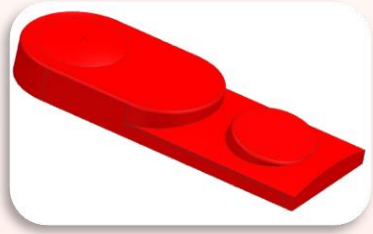


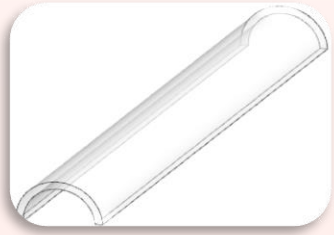


Cleaner Head Parts

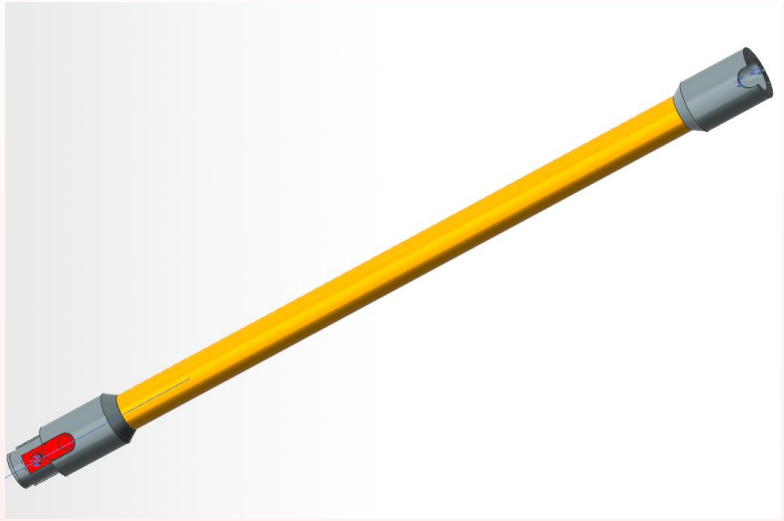






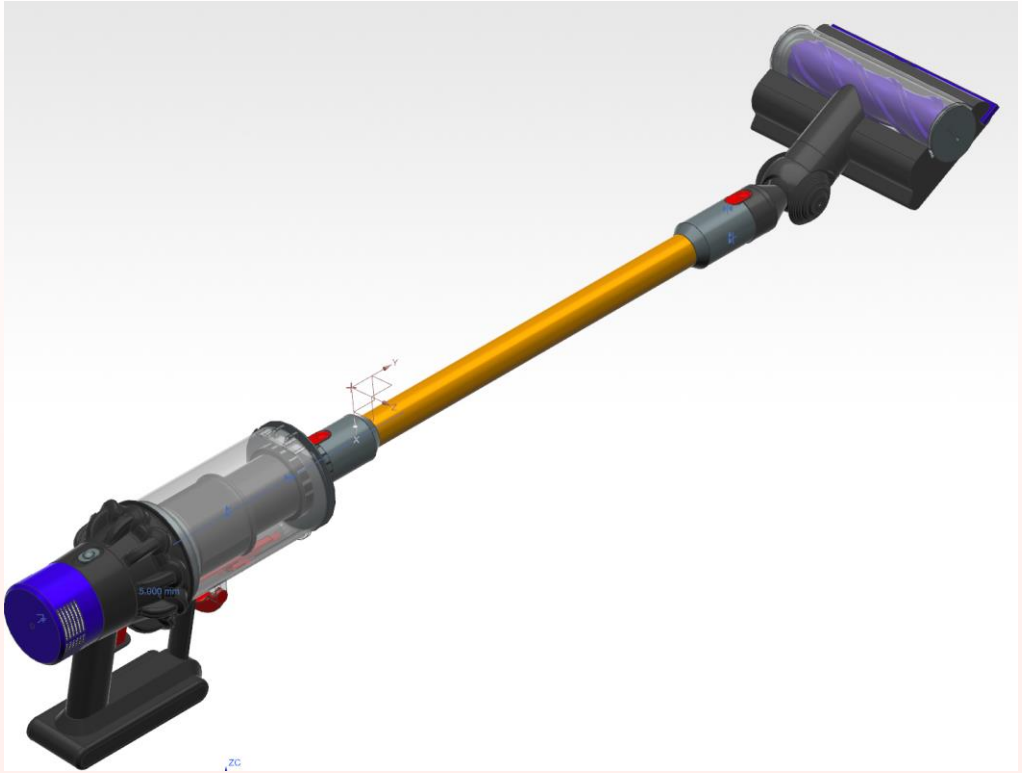


Stick & Cleaner Head Subassemblies



Dustbin and Main Body Subassembly

Full Assembly



Modeling and Assembly Challenges

- ✓ Size mismatch on parts
- ✓ NX assembly mates are harder to use
- ✓ Could not take apart the vacuum cleaner
- ✓ Difficult to measure curvature

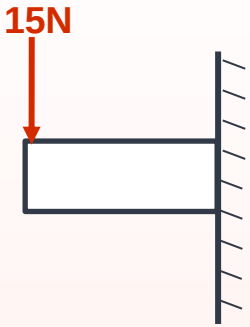
FEA Scenario #1

Force on dustbin stopper

- Common problem faced by users
- Crack formation due to cyclic loading

FEA Scenario #1

Force on dustbin stopper

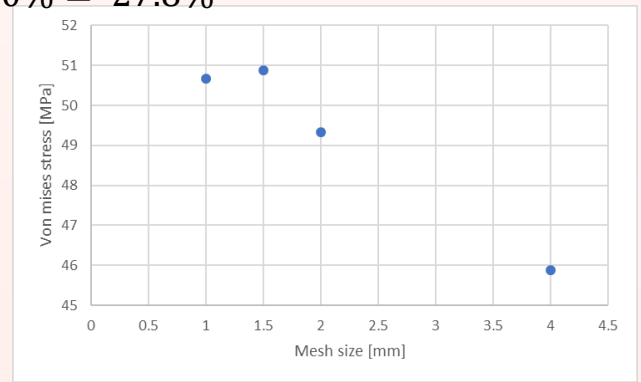


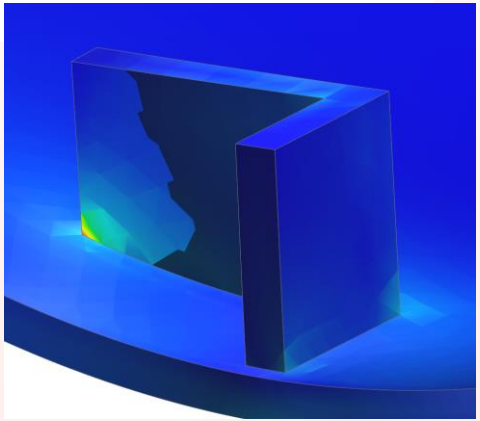
$$I_z = \frac{1}{12}bh^3 = \frac{1}{12}(5)(1)^3 = \frac{5}{12}mm^4$$

$$\sigma_x = \frac{My}{I} = \frac{15(4)(0.5)}{\frac{5}{12}} = 70.2\ MPa$$

$$\%\ error = \frac{70.2 - 50.67}{70.2} \times 100\% = 27.8\%$$

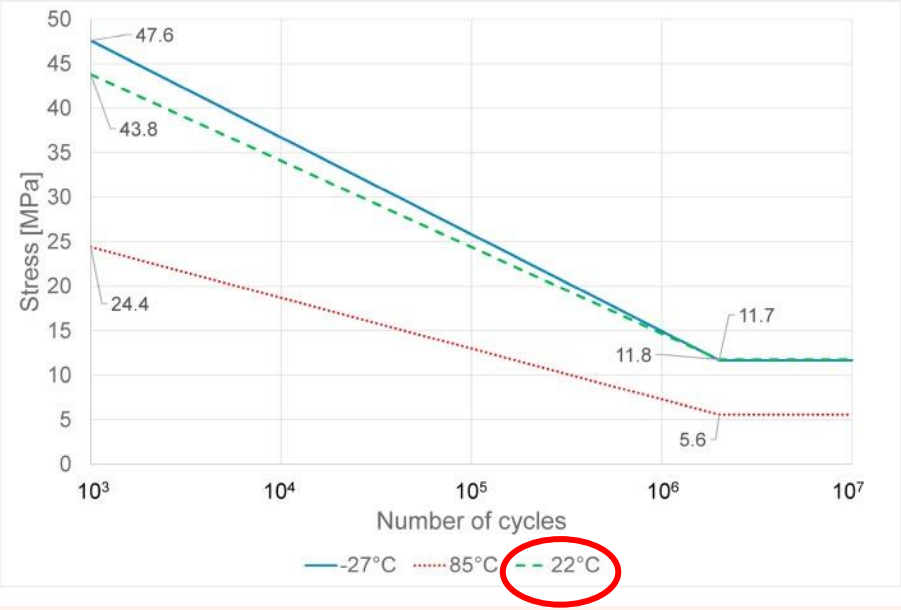
Max Stress: 50.67MPa





FEA Scenario #1

Force on dustbin stopper

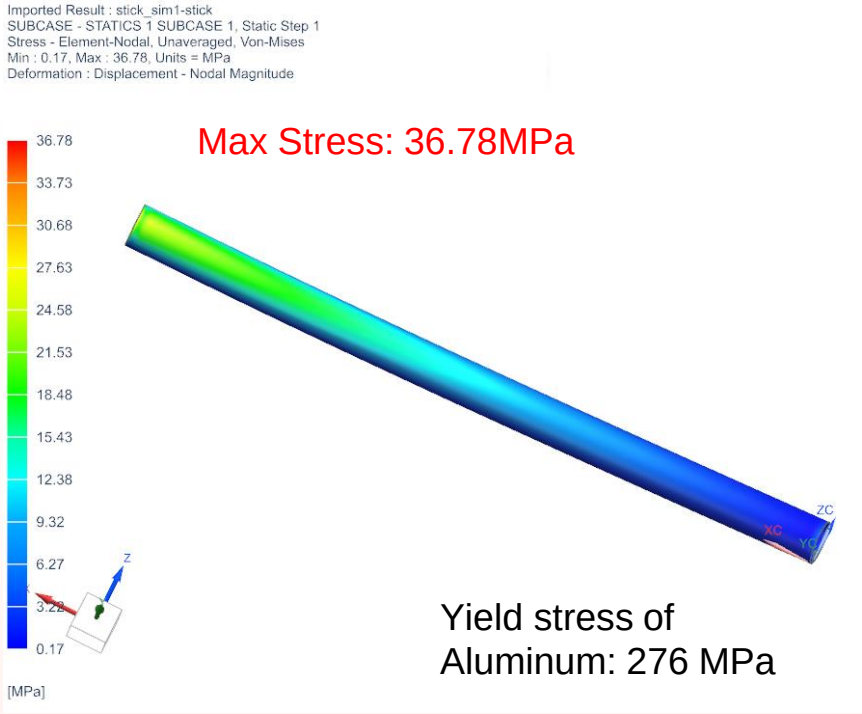


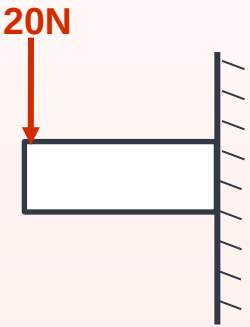
- ✓ Extrapolated 22 degrees Celsius
- ✓ 50 MPa is estimated to experience fatigue failure at around 500 cycles.
- ✓ If vacuum is cleaned out 2x a week
- ✓ It will last for 5 years

FEA Scenario #2

Force on end of vacuum wand

- Force applied on end of vacuum wand to simulate scenario of using wand to hit a cockroach

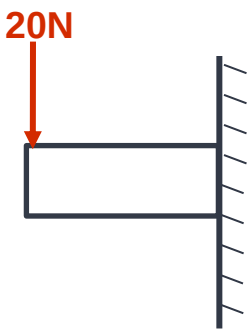


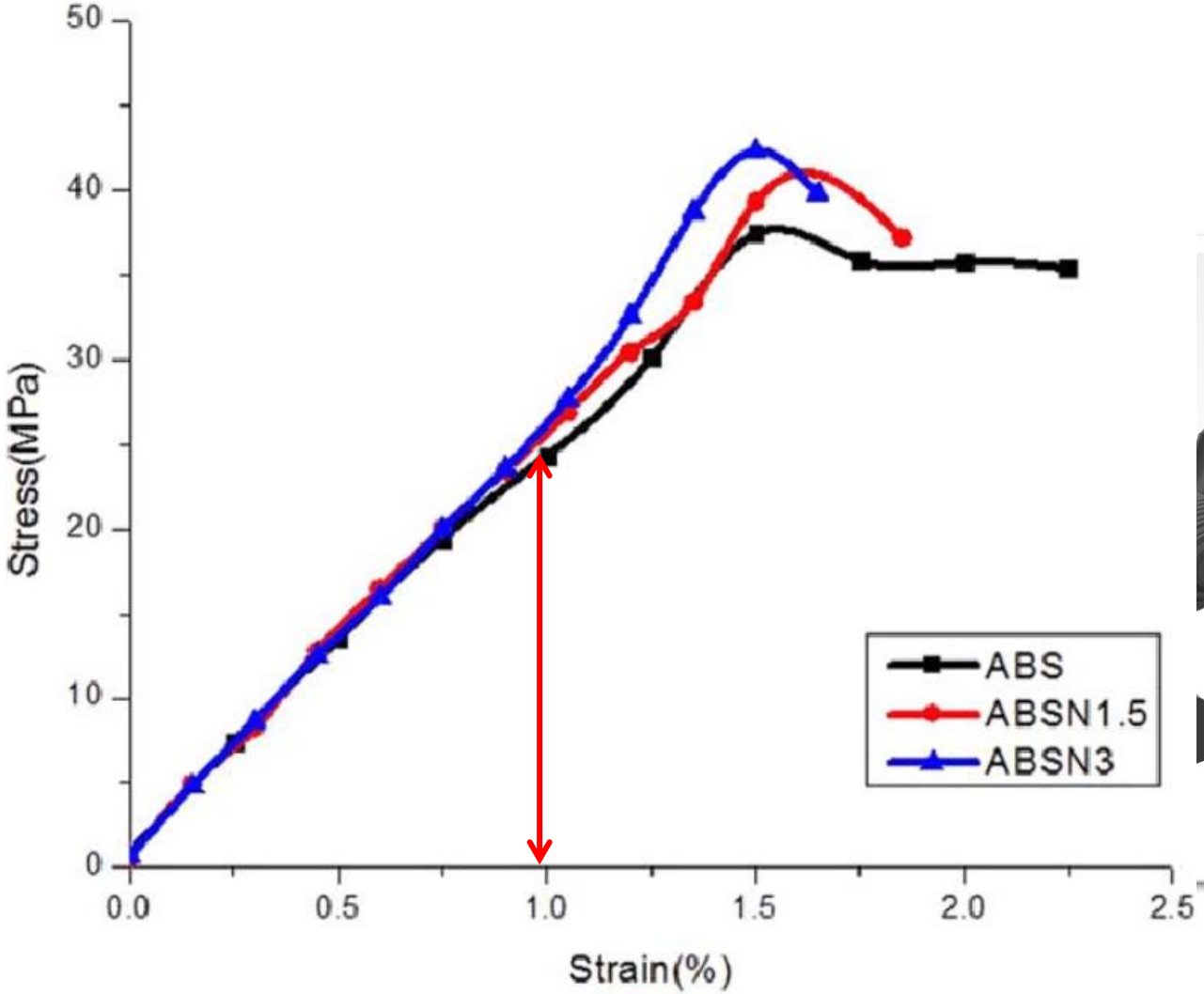


$$I_z = \frac{\pi}{64}\left(d_o^4 - d_i^4\right) = \frac{\pi}{64}(36.3^4 - 35.3^4) = 9011\ mm^4$$

$$\sigma_x = \frac{My}{I} = \frac{(600)(20)(\frac{36.3}{2})}{9011} = 24.2\ MPa$$

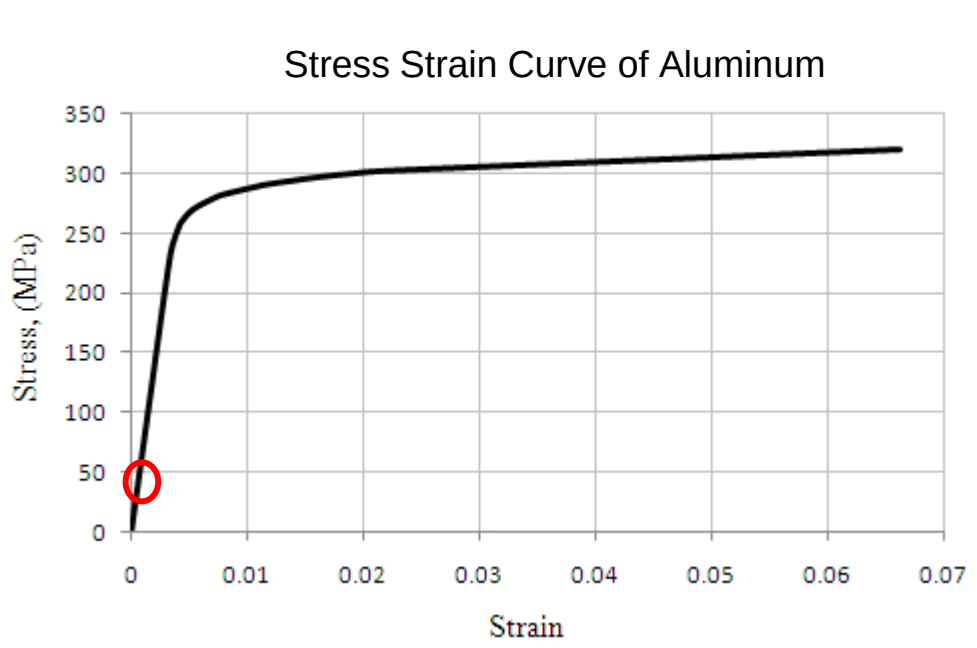
$$\%\ error = \frac{36.78 - 24.2}{24.2} \times 100\% = 52\%$$

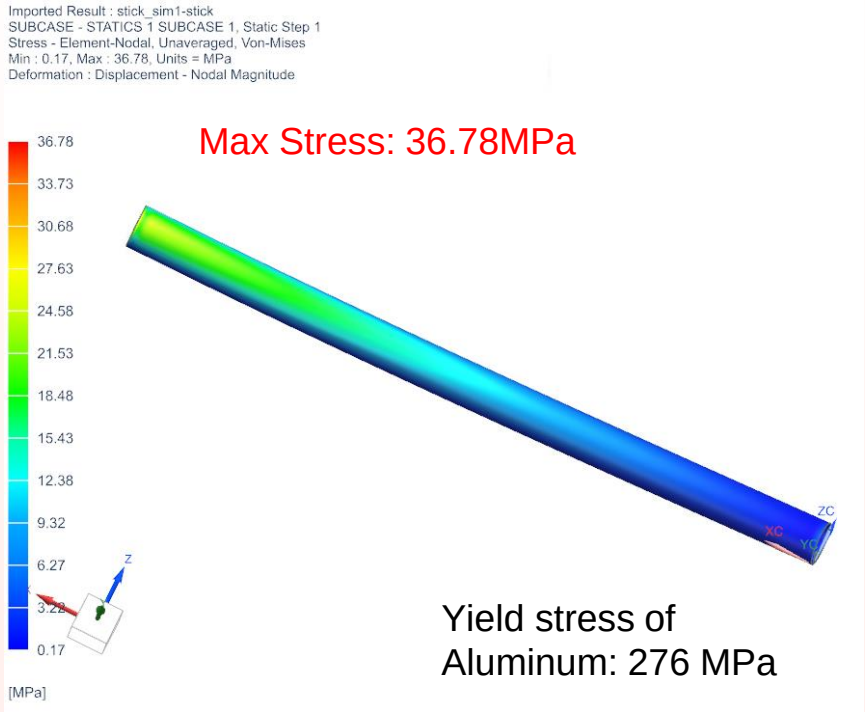

20N


Stress(MPa)
Strain(%)
0
10
20
30
40
50
0.0
0.5
1.0
1.5
2.0
2.5
ABS
ABSN1.5
ABSN3

FEA Scenario #2

Force on end of vacuum wand





FEA Scenario #3

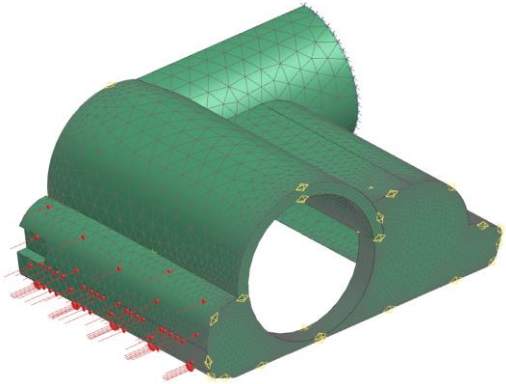
Force on front face of cleaner head

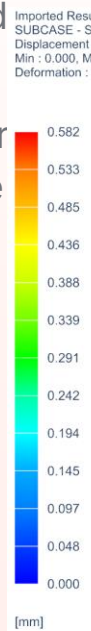
- Fixed on inner end of cleaner head
- Results – The cleaner head has largest displacement at the center of the cleaner head (0.58mm displacement)
- Stress distributed over front surface of cleaner head, and has a low pressure of ~9MPa on the connection between transparent and cleaner head piece

$$y_{max} = \frac{5wl^4}{384EI} = \frac{(5)(20)(245)^4}{(384)(2000)\left(\frac{\pi}{64}\left(d_o^4 - d_i^4\right)\right)}$$

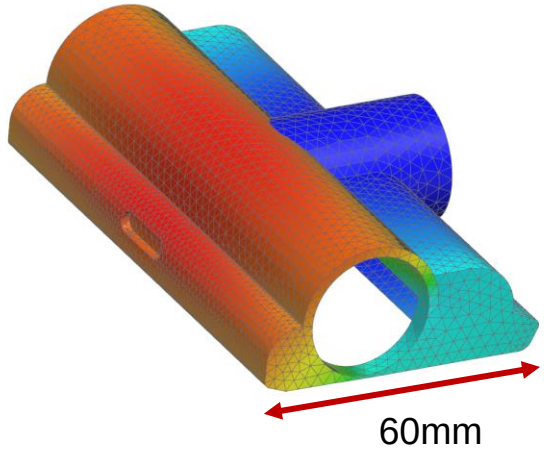
$$= 0.949\ mm$$

$$\%\ error = \frac{0.949 - 0.582}{0.949} \times 100\% = 38.7\%$$





Max Displacement: 0.582mm

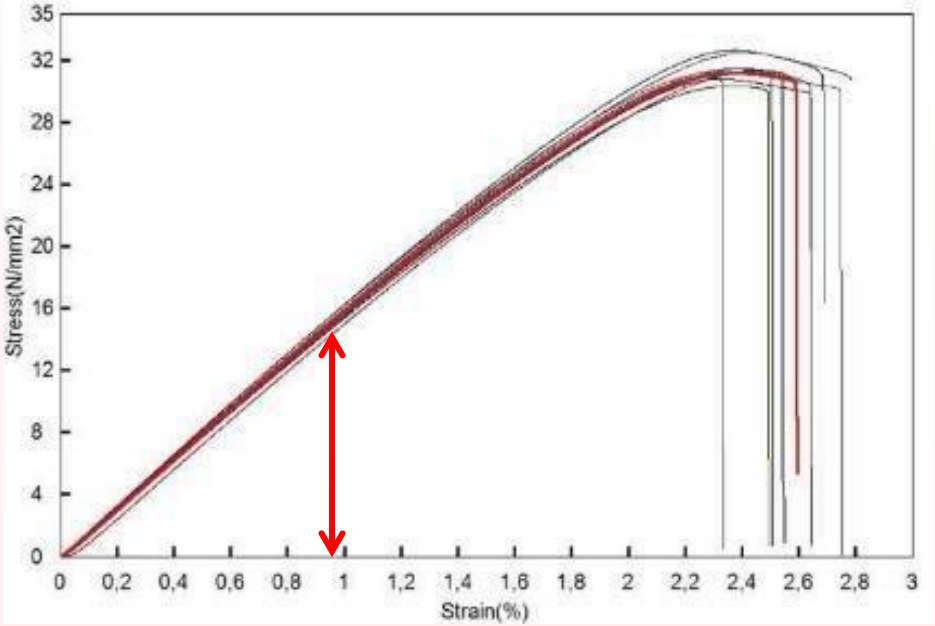


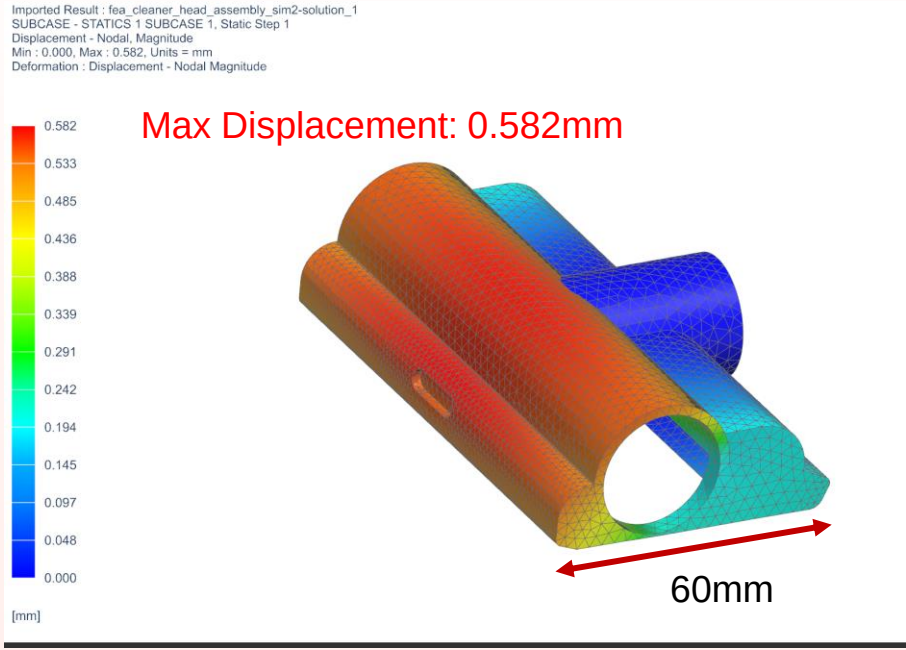
FEA Scenario #3

Force on front face of cleaner head

$$Strain = \frac{0.582mm}{60mm} * 100\% = 0.97\%$$

Stress Strain Curve of ABS





Suggested Improvements for Dyson

- Results show that Dyson Cyclone V10 will not suffer major damage from our loading scenarios
- Only the first scenario with the locking tab shows the most possible damage
  - Improvement: make the tab thicker or from a stronger material
- From Dyson users online it seems most damage is from fatigue and extended or harsh use
- Dyson does earn its name of ‘overengineered vacuum’

Conclusion

- FEA is only useful when modelled correctly
- Tried to solve dynamic scenario with static FEA
- Many challenges that comes with identifying the right boundary conditions based on real life scenarios
- Mesh control is important as the node sizes cannot be too large or too small to get accurate results
- Hand calculations show that FEA results are not always accurate, need additional support and analysis, and must be used with caution

Thank You!

Any Questions?