Clean Cut for Rubber Hose

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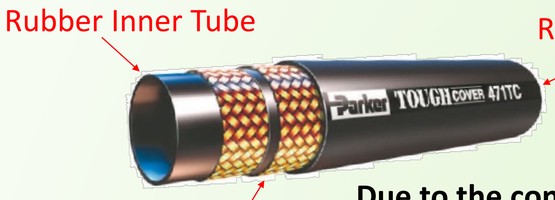
Background

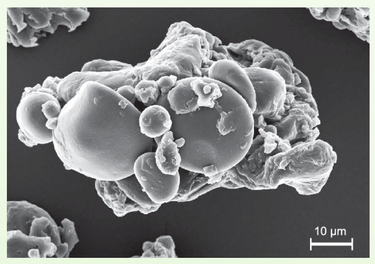
- Contamination is a major concern in hydraulic and pneumatic systems
- Abrasive cutting wheels and scalloped edge blades generate smoke and debris which requires a secondary flushing operation to clean the inner tube area of the hose
- Objectives: (1) Evaluate alternative cutting methods, and (2) Design a production-style cutting process that eliminates the need for secondary cleaning



Due to the construction of the hose, available cutting methods are limited

Specifications

- Cut hose meets 16/14/11 cleanliness ratings per ISO 4405, 4406 and 4407



Milled Flour: 25 µm

- Cut hose meets angularity, fraying, and deformation specifications per SAE J517

Red Blood Cells: 8 µm

- Cost Target: $3,000

Most damaging contaminants in hydraulic systems are normally between 6 and 14 microns

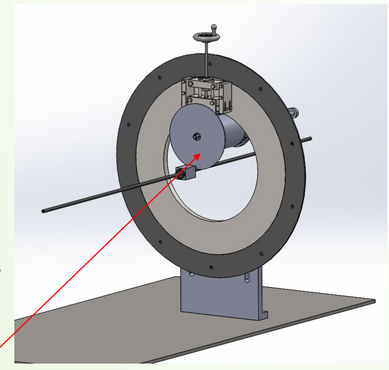
Research & Development

Methodology: Understand traditional cutting processes and weigh against alternative cutting methods

- EDM
- EBM
- Hot Air Jet
- Plasma
- Laser
- Ultrasonic
- Abrasive Waterjet
- Cold forming with pipe cutter
- Wet Saw
- End Mill
- Shear
- Guillotine
- Waterjet
- Laser Microjet

Final Selection: Two-Phase Cut

- Phase One: Cut through cover and reinforcement, inner tube serves as a physical contamination barrier
- Phase Two: Guillotine shears through inner tube, producing no debris

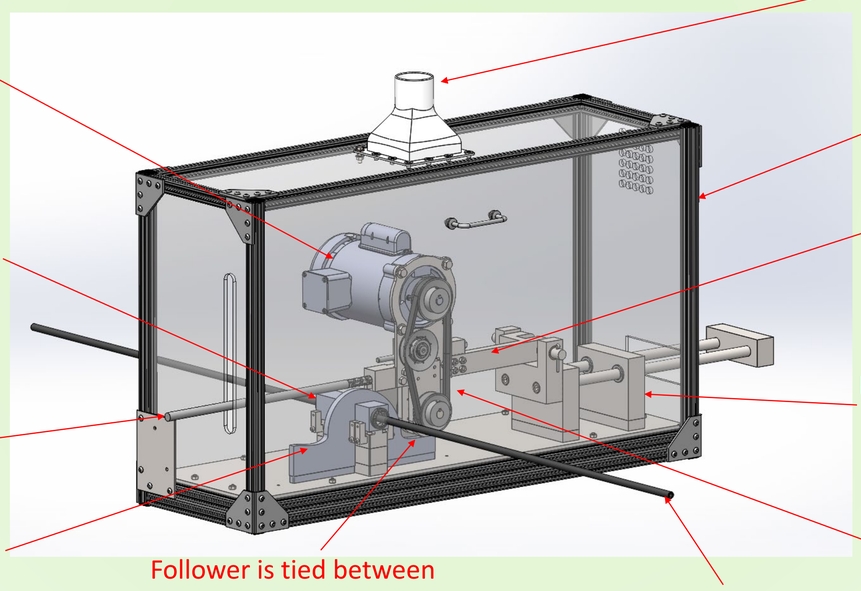


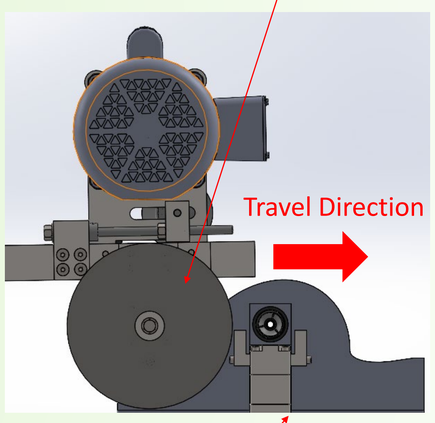
Phase One is accomplished via manually-operated, 360-degree orbital saw blade

Due to high complexity and cost restraints, the first iteration was rejected

Final Iteration

- Phase One is accomplished via modified compound miter saw design
- Completed in two passes: (1) Sawblade travels around the periphery of the top portion of hose, and (2) The hose is flipped 180 degrees in workholding to complete the final pass
- Hand-operated shearing tool accomplishes Phase Two of cut





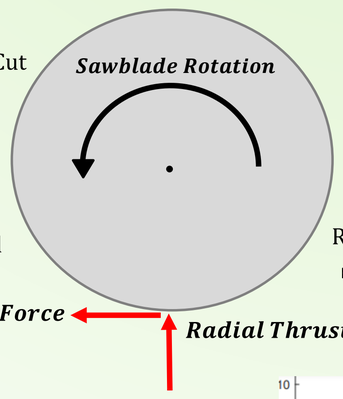
Analysis

Sawblade Motor Sizing

Material	Specific energy W-s/mm³	Specific energy hp-min/in³
Aluminum alloys	0.4–1	0.15–0.4
Cast irons	1.1–5.4	0.4–2
Copper alloys	1.4–3.2	0.5–1.2
High-temperature alloys	3.2–8	1.2–3
Magnesium alloys	0.3–0.6	0.1–0.2
Nickel alloys	4.8–6.7	1.8–2.5
Refractory alloys	3–9	1.1–3.5
Stainless steels	2–5	0.8–1.9
Steels	2–9	0.7–3.4
Titanium alloys	2–5	0.7–2

Material Removal Rate = Depth of Cut × Width of Cut × Feed Rate

Power = Material Removal Rate × Specific Energy of Material



Calculation of Cutting Forces

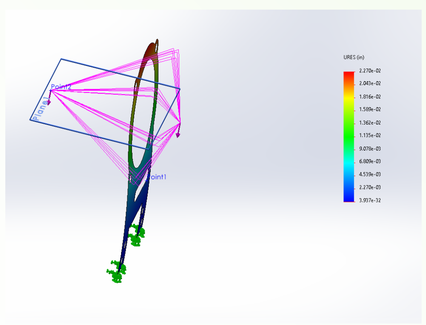
$$\text{Torque} = \frac{\text{Power}}{\text{Rotational Speed}}$$

$$\text{Tangential Cutting Force} = \frac{\text{Torque}}{\text{Sawblade Radius}}$$

$$\text{Radial Thrust Force} = \text{Tangential Cutting Force} \times 1.3$$

Ref: Serope Kalpakjian and Steven R Schmid. *Manufacturing Engineering and Technology*. Upper Saddle River, Nj, Pearson, 2014.

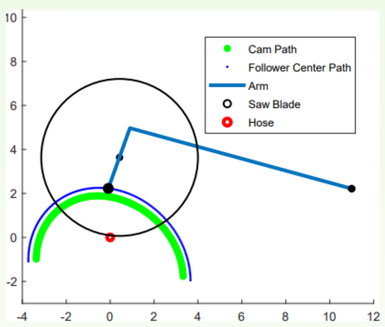
Motor Mount Analysis



Material = 0.25” A36 Steel
Deflection = 0.027”
Von Mises Stress = 6,200 psi

Fixed at bottom legs and loads are applied at center of gravity of motor and drive pulley

Matlab Cam Profile

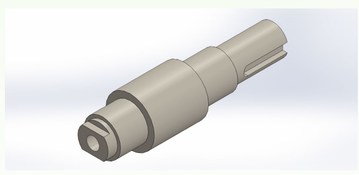


Shaft Stress Analysis

The critical stress elements are located at the bearing shoulder fillets

Analyze at infinite life using the DE-Goodman Failure Criterion:

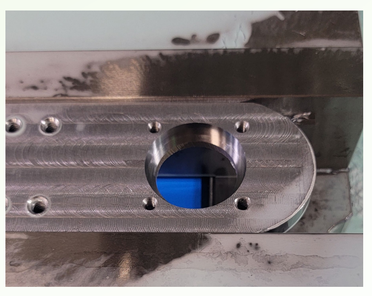
$$\text{F. O. S.} = \frac{\pi d^3}{16}\left(\frac{\sqrt{4(K_f M_a)^2 + 3(K_{fs} T_a)^2}}{S_e} + \frac{\sqrt{4(K_f M_m)^2 + 3(K_{fs} T_m)^2}}{S_{ut}}\right)^{-1} = 11.8$$



Production

EDM Holes for Press Fit Bushings

Milling Saw Shaft



CNC Milled Bearing Blocks

Milling Saw Arm