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METC143

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Problem Statement:

The task is to design a cable that will support a 60-ton vehicle. The cable is 25-foot-long and can have an elastic deformation of no more than 10%. Using the Modulus of Elasticity for various metals design a cable. Use standard cable diameter sizes listed below (units are inch):

2
1 3/4
1 1/2
1 1/4
1
3/4
1/2
3/8
1/4
3/16
1/8
1/16
1/32
1/64

Introduction:

First placed all variable into an excel worksheet. Then used to the excel worksheet and the known equations for stress, elongation, and Hooks law to calculations needed, which are shown

throughout this report. This report also includes research done through Matweb to show that elements composition of each material.

Results:

Materials composition:

2014-T6 Aluminum:

Aluminum, Al	90.4 - 95 %	90.4 - 95 %
Chromium, Cr	<= 0.10 %	<= 0.10 %
Copper, Cu	3.9 - 5.0 %	3.9 - 5.0 %
Iron, Fe	<= 0.70 %	<= 0.70 %
Magnesium, Mg	0.20 - 0.80 %	0.20 - 0.80 %
Manganese, Mn	0.40 - 1.2 %	0.40 - 1.2 %
Other, each	<= 0.05 %	<= 0.05 %
Other, total	<= 0.15 %	<= 0.15 %
Silicon, Si	0.50 - 1.2 %	0.50 - 1.2 %
Titanium, Ti	<= 0.15 %	<= 0.15 %
Zinc, Zn	<= 0.25 %	<= 0.25 %

1045 Steel:

Carbon, C	0.42 - 0.50 %	0.42 - 0.50 %
Iron, Fe	98.51 - 98.98 %	98.51 - 98.98 %
Manganese, Mn	0.60 - 0.90 %	0.60 - 0.90 %
Phosphorous, P	<= 0.040 %	<= 0.040 %
Sulfur, S	<= 0.050 %	<= 0.050 %

Copper:

Copper, Cu	100%	100%

Titanium Ti-6Al-4V (Grade 5), Annealed:

Aluminum, Al	5.5 - 6.75 %	5.5 - 6.75 %
Carbon, C	<= 0.080 %	<= 0.080 %
Hydrogen, H	<= 0.015 %	<= 0.015 %
Iron, Fe	<= 0.40 %	<= 0.40 %
Nitrogen, N	<= 0.030 %	<= 0.030 %
Other, each	<= 0.050 %	<= 0.050 %
Other, total	<= 0.30 %	<= 0.30 %
Oxygen, O	<= 0.20 %	<= 0.20 %
Titanium, Ti	87.725 - 91 %	87.725 - 91 %
Vanadium, V	3.5 - 4.5 %	3.5 - 4.5 %

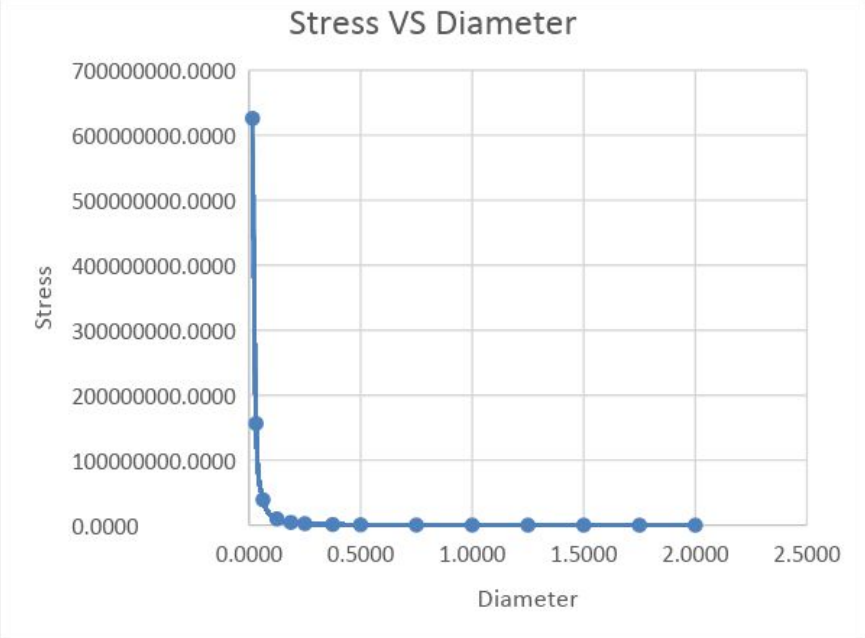
Calculated diameter based on Modulus of Elasticity:

Theoretical Area:	(in^2)	Diameter:	
Steel:	0.04197	0.2312	in
Copper:	0.08394	0.3269	in
Titanium:	0.10492	0.3655	in
Aluminum:	0.12590	0.4004	in

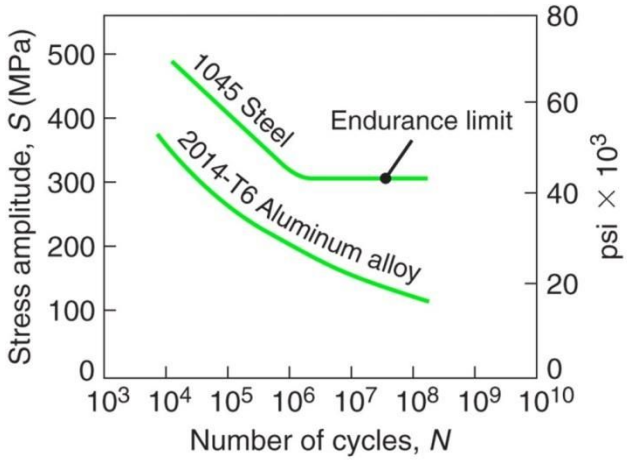
Stress Calculations based on given diameters:

Stress:		Diameters:	
38197.19	psi	2.0000	in
49890.20	psi	1.7500	in

67906.11	psi	1.5000	in
97784.80	psi	1.2500	in
152788.75	psi	1.0000	in
271624.44	psi	0.7500	in
611154.98	psi	0.5000	in
1086497.74	psi	0.3750	in
2444619.93	psi	0.2500	in
4345990.98	psi	0.1875	in
9778479.70	psi	0.1250	in
39113918.81	psi	0.0625	in
156455675.26	psi	0.0313	in
625822701.03	psi	0.0156	in



Fatigue Analysis:



Selected Diameter:

Theoretical									
Area:	(in^2)	Diameter:		Best fit Diameters:		Area:	Stress:		
	0.0400					0.04908	244462		
Steel:	0	0.2257	in	0.25	in	7	0	psi	
	0.1200								
Aluminum:	0	0.3909	in	0.5	in	0.19635	611155	psi	

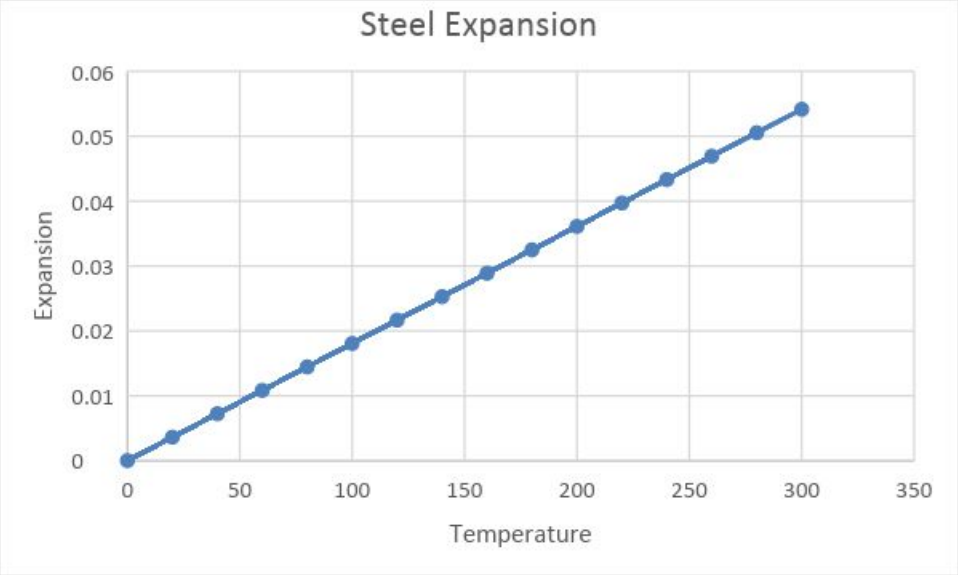
With the selected diameter of 0.25 for steel that ranges the stress close to 250,0000 psi, so the cycles do not match up. The same goes for aluminum with the diameter of 0.5 and the stress close to 60,000psi.

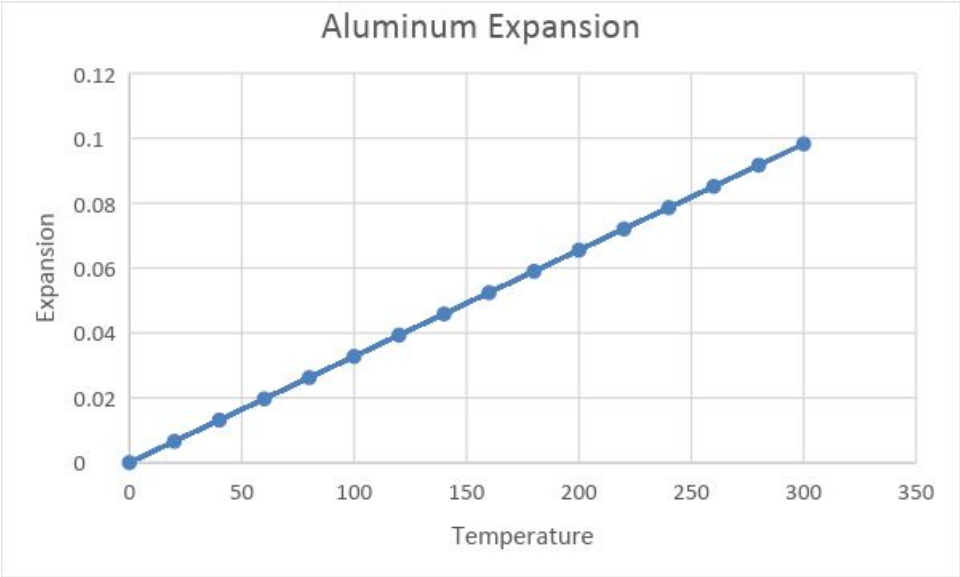
Thermal Analysis:

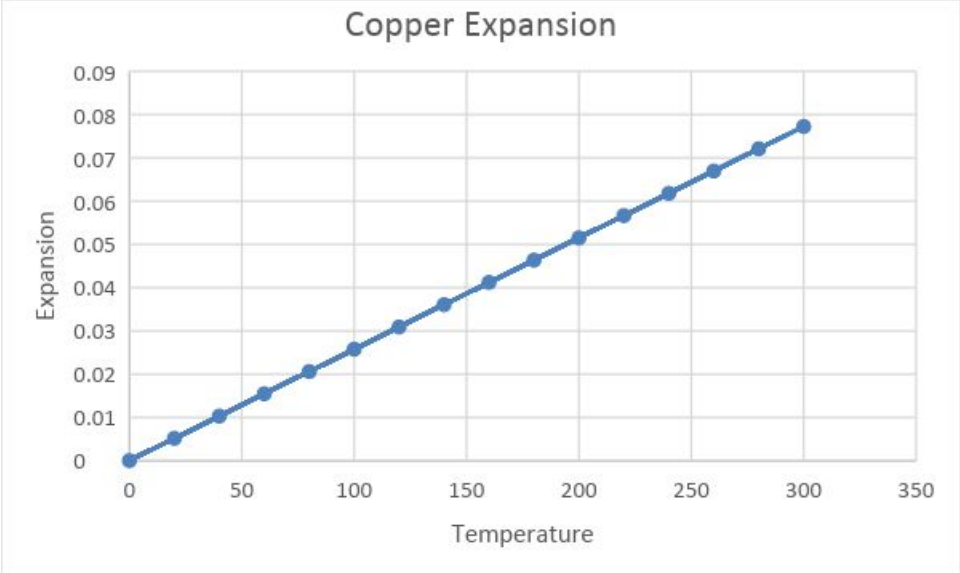
Thermal Expansion:

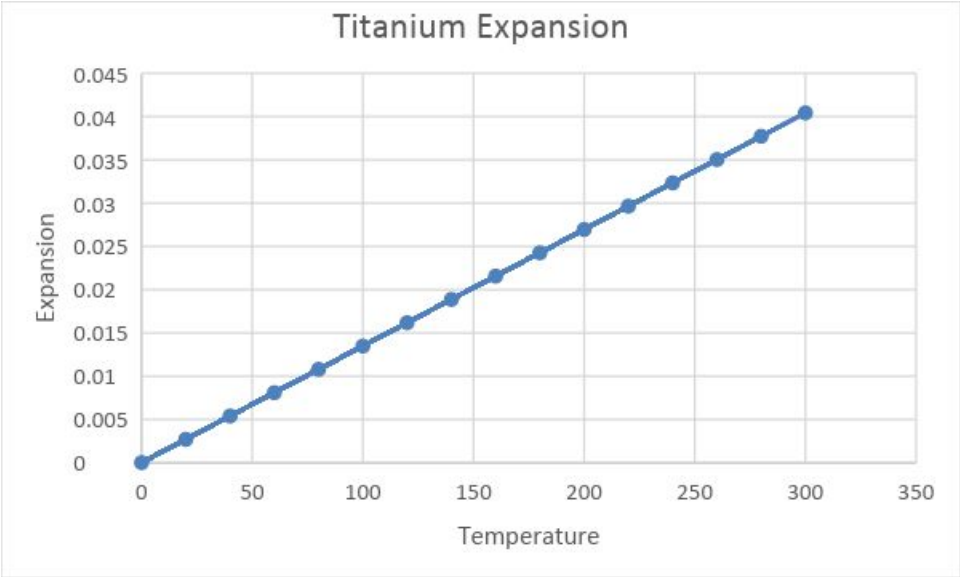
Temperature: [°F]	Steel:	Aluminum:	Copper:	Titanium:

0	0	0	0	0
20	0.0036	0.0066	0.0052	0.0027
40	0.0072	0.0131	0.0103	0.0054
60	0.0108	0.0197	0.0155	0.0081
80	0.0144	0.0262	0.0206	0.0108
100	0.0181	0.0328	0.0258	0.0135
120	0.0217	0.0393	0.0309	0.0162
140	0.0253	0.0459	0.0361	0.0189
160	0.0289	0.0524	0.0412	0.0216
180	0.0325	0.0590	0.0464	0.0243
200	0.0361	0.0655	0.0515	0.0270
220	0.0397	0.0721	0.0567	0.0296
240	0.0433	0.0786	0.0618	0.0323
260	0.0469	0.0852	0.0670	0.0350
280	0.0505	0.0917	0.0721	0.0377
300	0.0542	0.0983	0.0773	0.0404




Aluminum Expansion
0.12
0.1
0.08
0.06
0.04
0.02
0
Expansion
0
50
100
150
200
250
300
350
Temperature


Copper Expansion
0.09
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
Expansion
0
50
100
150
200
250
300
350
Temperature



Conclusion:

The material mast suited for the job is steel because you can use the least amount of material and maintain strength. The best diameter for steel is 1/4in. the best diameter for aluminum is 1/2in. Titanium and copper can both be 3/8in.