CABLE DESIGN PROJECT

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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):

Introduction

In order to design a cable, we need to take in consideration the material that we need to use. To do so, we first need to identify the properties of the material that we desire to choose. For corrosion purposes. Then we can calculate the diameter and the stress of the material using the formula below. In addition to analyze the fatigue and thermal expansion of the material in order to better identified the right material to use.

Stress $=F/A$

Thermal Expansion$= \alpha \, l_o \, \Delta t$

Results :

component elements properties of material to analyze

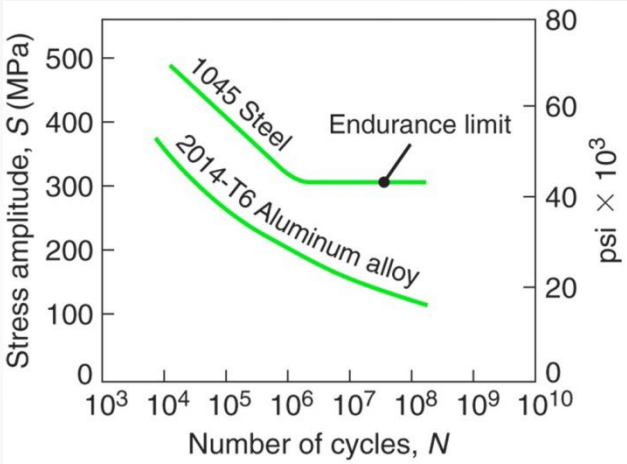
Component Elements Properties	1045 Steel	2014-T6 Aluminum	Copper	Titanium Ti-6Al-4V (Grade 5), Annealed
Carbon, C	0.42 - 0.50 %			<= 0.080 %
Iron, Fe	98.51 - 98.98 %	<= 0.70 %		<= 0.40 %
Manganese, Mn	0.60 - 0.90 %	0.40 - 1.2 %		
Phosphorous, P	<= 0.040 %			
Sulfur, S	<= 0.050 %			
Aluminum, Al		90.4 - 95 %		5.5 - 6.75 %
Chromium, Cr		<= 0.10 %		
Copper, Cu		3.9 - 5.0 %	100%	
Magnesium, Mg		0.20 - 0.80 %		
Silicon, Si		0.50 - 1.2 %		
Titanium, Ti		<= 0.15 %		87.725 - 91 %
Zinc, Zn		<= 0.25 %		
Hydrogen, H				<= 0.015 %
Nitrogen, N				<= 0.030 %
Oxygen, O				<= 0.20 %
Vanadium, V				3.5 - 4.5 %

Proposed Diameter to use:

Material to be analyzed	modulus of elasticity	force (lb.)	L_o = initial length (in)	dl (change in length)	strain	stress	Area (in^2)	Diameter (in)	proposed diameter (in)
Aluminum	10,000,000	120000	300	30	0.1	1000000	0.12	0.39	1/2
Steel	30000000	120000	300	30	0.1	3000000	0.04	0.23	1/4
Copper	15,000,000	120000	300	30	0.1	1500000	0.08	0.32	3/8
Titanium	12,000,000	120000	300	30	0.1	1200000	0.1	0.36	3/8

Fatigue Analysis

Based on my calculation, the maximum number of cycle for steel will be less than 10^3 psi and for aluminum it will be also less than that which is not normal. So, by changing my diameter for steel to ½ and for aluminum to ¼ I am able to obtain: a value of 611155 (psi) for steel and 244619.926 (psi) for aluminum which are more reasonable value. Consequently, based on those values the maximum number of cycle for steel is about 10^5 cycles and for aluminum it is about 10^7 cycles.



	Stress Calculations Based on all common diameter size			
diameter	radius	Area	force	Stress
2	1	3.141592654	120000	38197.18634
1 3/4	7/8	2.405281875	120000	49890.20257
1 1/2	3/4	1.767145868	120000	67906.10905
1 1/4	5/8	1.22718463	120000	97784.79704
1	1/2	0.785398163	120000	152788.74537
3/4	3/8	0.441786467	120000	271624.43621
1/2	1/4	0.196349541	120000	611154.98147
3/8	1/5	0.110446617	120000	1086497.74484
1/4	1/8	0.049087385	120000	2444619.92589
3/16	3/32	0.027611654	120000	4345990.97936
1/8	1/16	0.012271846	120000	9778479.70357
1/16	1/32	0.003067962	120000	39113918.81426
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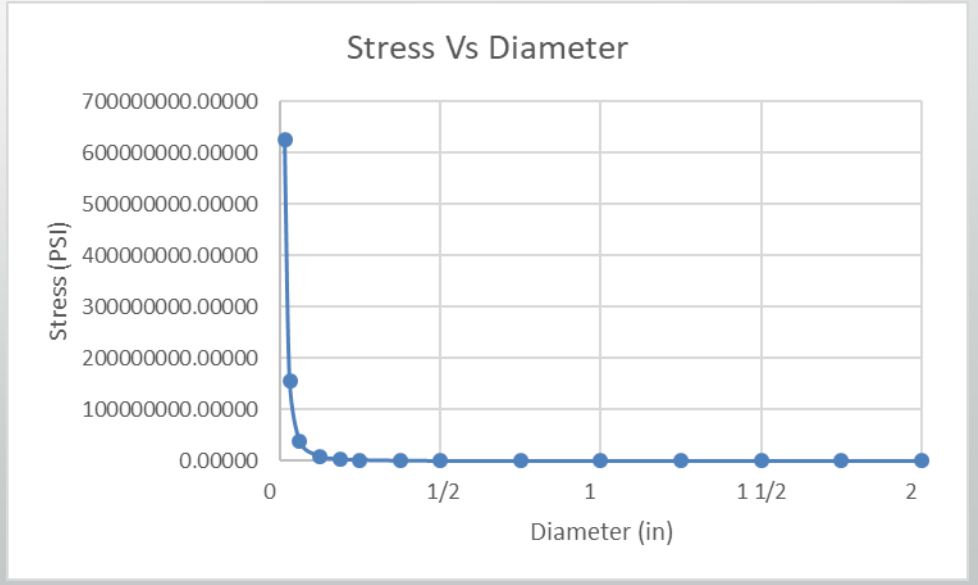
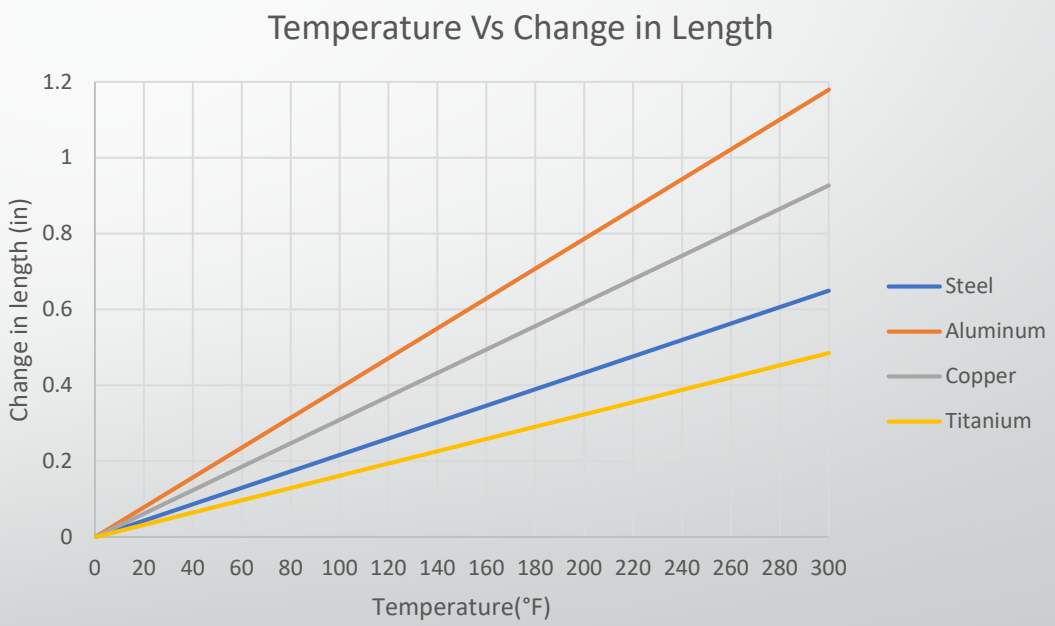


Thermal Analysis

Thermal Expansion for each material

temperature	length(in)	Steel thermal expansion	Aluminum thermal expansion	Copper thermal expansion	Titanium thermal expension
0	0	0	0	0	0
20	30	0.04332	0.0786	0.0618	0.03234
40	300	0.08664	0.1572	0.1236	0.06468
60	300	0.12996	0.2358	0.1854	0.09702
80	300	0.17328	0.3144	0.2472	0.12936
100	300	0.2166	0.393	0.309	0.1617
120	300	0.25992	0.4716	0.3708	0.19404
140	300	0.30324	0.5502	0.4326	0.22638
160	300	0.34656	0.6288	0.4944	0.25872
180	300	0.38988	0.7074	0.5562	0.29106
200	300	0.4332	0.786	0.618	0.3234
220	300	0.47652	0.8646	0.6798	0.35574
240	300	0.51984	0.9432	0.7416	0.38808
260	300	0.56316	1.0218	0.8034	0.42042
280	300	0.60648	1.1004	0.8652	0.45276
300	300	0.6498	1.179	0.927	0.4851



Conclusion

The material that we will use for our cable will be steel due to the fact that it has a great strength and it will be able to handle a larger load. The smaller diameter that we can use for steel is ¼ inches. However it is preferable to use ½ inches for stength purposed.