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METC143

12/14/2016

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.

Introduction:

The process I used was to first determine the thermal expansive properties of each material because I already had the data needed available to do so, and to give me some general ideas of the properties of each material based on temperature. After running the thermal calculations, I found that copper and aluminum had the best resistance to thermal expansion all around. After that I then ran a basic stress calculation to determine in PSI the amount of force that the truck was going to place on the cable. After that I needed to calculate per diameter what the cross-sectional area was in sq. inches so I could match units with the length of cable, which I also converted to inches to keep a common unit. I used that information, along with the modulus of elasticity to calculate per load and material what the amount in inches of elongation each diameter per material type was going to undergo. Finally, I converted that information to percent elongation to determine what cable diameter was required to satisfy the less than 10 percent elongation requirement.

Results:

Matweb Tables

Aluminum

|  |
| --- |
|  |
| **Component Elements Properties** | **Metric** | **English** | **Comments** |
| Aluminum, Al | 90.4 - 95 % | 90.4 - 95 % | As remainder |
| 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 % |  |

Steel

|  |  |  |  |
| --- | --- | --- | --- |
| **Component Elements Properties** | **Metric** | **English** | **Comments** |
| Carbon, C | 0.42 - 0.50 % | 0.42 - 0.50 % |  |
| Iron, Fe | 98.51 - 98.98 % | 98.51 - 98.98 % | As remainder |
| Manganese, Mn | 0.60 - 0.90 % | 0.60 - 0.90 % |  |
| Phosphorous, P | <= 0.040 % | <= 0.040 % |  |
| Sulfur, S | <= 0.050 % | <= 0.050 % |  |

Copper

|  |  |  |  |
| --- | --- | --- | --- |
| **Component Elements Properties** | **Metric** | **English** | **Comments** |
| Copper, Cu | 100 % | 100 % |  |
|  | | | |

Titanium

|  |  |  |  |
| --- | --- | --- | --- |
| **Component Elements Properties** | **Metric** | **English** | **Comments** |
| 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 % | As Balance; Elemental Composition per ASTM B265 |
| Vanadium, V | 3.5 - 4.5 % | 3.5 - 4.5 % |  |

Smallest Calculated Diameter Required:

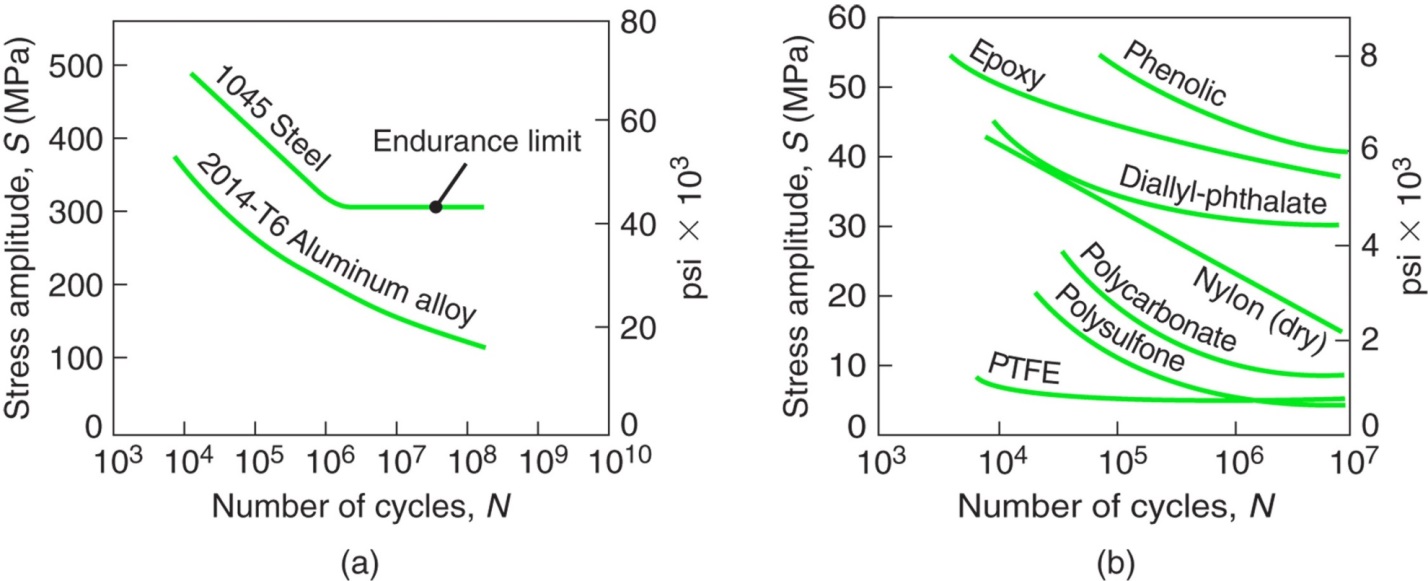
|  |  |
| --- | --- |
| Aluminum | 1/8 |
| Steel | 1/16 |
| Copper | 1/8 |
| Titanium | 1/8 |

Fatigue Analysis:

Stress Generated for Steel 1/16 is 611465 PSI

Stress Generated for Aluminum is 305732 PSI at 1/8

Based on this graph, the steel would survive 10^5, and aluminum would survive 10^5 and a half.

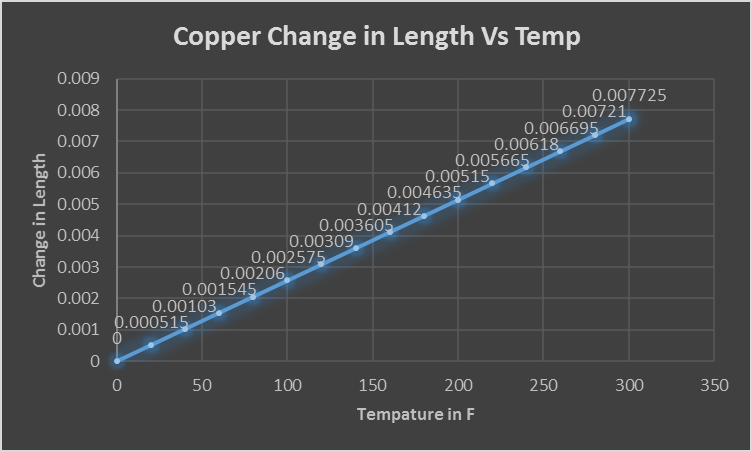
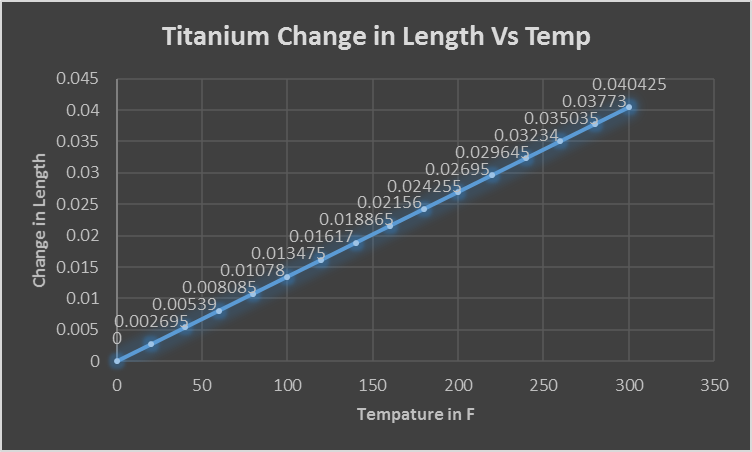
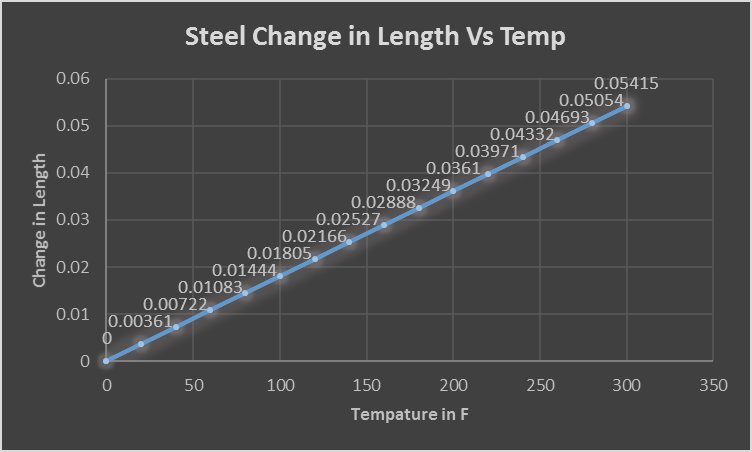
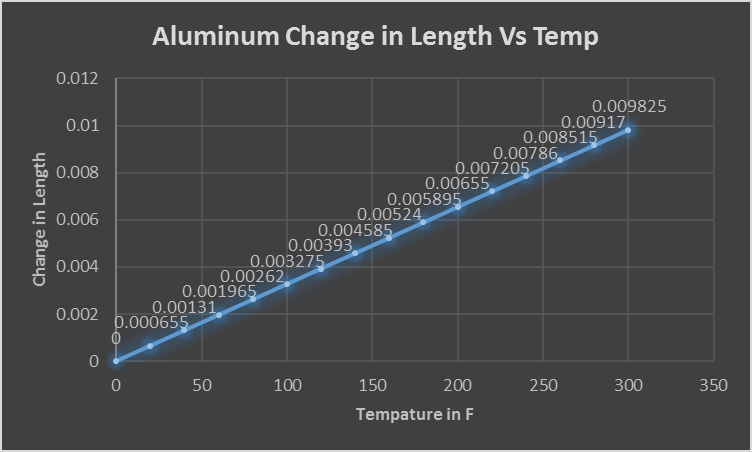


Thermal Analysis:









Conclusion:

Coming down to cable diameter selections, Based on the elongation numbers, coupled with the thermal expansion numbers, I would up the required diameter per each material by one level, to both allow for some form of safety factor and to counter thermal expansion so for Aluminum, Copper, and Titanium I would select 3/16, and for Steel I would select 1/8

Among the four materials, I would choose Steel for this use case. Understanding that among the four types of cable it has the highest thermal expansion rate, it also has the least amount of elongation and this allows for a less dense cable to be used, and counters the higher thermal expansion. Along with this, steel is one of the most abundant types of cable, available, and as far as cost goes due to its abundance, it is one of the cheaper options.