Problem_6_29

March 6, 2017

1 Problem 6.29 from Callister

A cylindrical specimen of aluminum having a diameter of 0.505 in (12.8 mm) and a guage length of 2.000 in (50.800 mm) is pulled in tension. Use the load - elongation characteristics shown in the following table to complete the following: 1. Plot the data as engineering stress versus engineering strain. 1. Compute the modulus of elasticity. 1. Determine the yield strength using a strain offset of 0.002. 1. Determine the ultimate tensile strength of this allow. 1. Determine the ductility in percent elongation. 1. Compute the modulus of resilience.

1.1 Read Values and Calculate Stress and Strain

The values given in the problem are stored in an external comma separated file. We read them into this notebook using pandas. This creates a DataFrame object.

```
In [1]: import pandas as pd; import numpy as np;from math import *
        Data=pd.read_csv('6_29.csv');
        Data.head(10)
```

Out[1]:

	Load (N)	Length (mm)
0	0	50.800
1	7330	50.851
2	15100	50.902
3	23100	50.952
4	30400	51.003
5	34400	51.054
6	38400	51.308
7	41300	51.816
8	44800	52.832
9	46200	53.848

We then calculate the stress and strain. In doing so we create new Numpy arrays since we are mainly need to numerical calculations.

```
In [2]: d=12.8; area=pi*(d/2)**2;
        Stress = Data["Load (N)"].values/area
```

```
In [3]: l_0=50.800
        Strain = (Data["Length (mm)"]-l_0).values/l_0
```

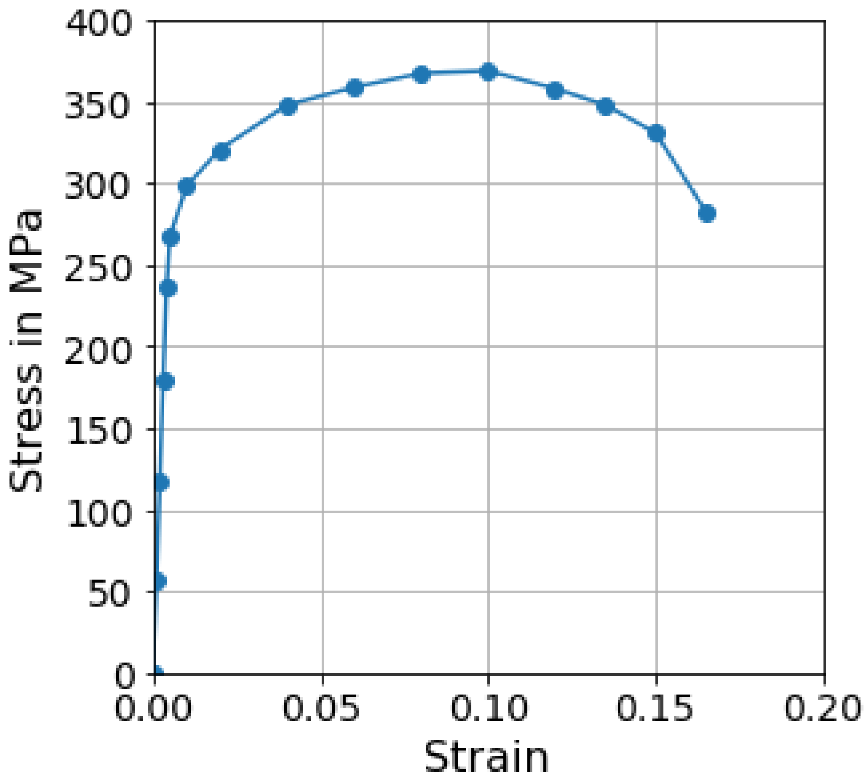
1.2 Plot the data as engineering stress versus engineering strain.

```
In [4]: from matplotlib import pyplot as plt
        import matplotlib
        %matplotlib inline
```

```
In [5]: def format_plot(a):
            """Format a plot for presenation.  Function takes one parameter, a matp
            fsx = 4.5
            fsy = 4.5

            a.tick_params(labelsize=14)
            a.xaxis.label.set_size(16)
            a.yaxis.label.set_size(16)
            a.title.set_size(16)
            a.get_figure().set_size_inches(fsx, fsy)
            a.grid(1)
```

```
In [6]: MyFigure, MyAxes = plt.subplots(1, 1);
        MyAxes.plot(Strain,Stress,'-o');MyAxes.set_xlabel("Strain");MyAxes.set_ylab
        MyAxes.set_xlim((0,0.20));MyAxes.set_ylim((0,400))
        format_plot(MyAxes)
```



1.3 Compute the modulus of elasticity

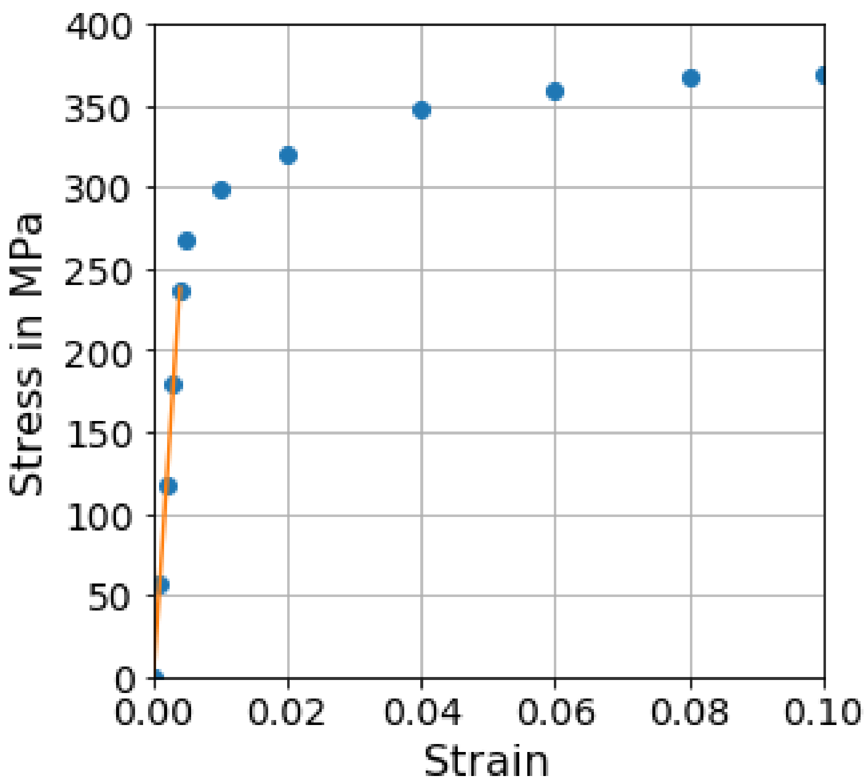
For this, we to calculate the slope of the first few data points. For this, we will use the linear regression function from SciPy

```
In [7]: from scipy.stats import linregress
        (m,b)=linregress(Strain[0:4],Stress[0:4])[0:2];
        print("The modulus of elasticity is {:.0f} MPA. \nThe intercept is {:3.1f}'
```

```
The modulus of elasticity is 60005 MPA.
The intercept is -1.6
```

We will now plot the data with the linear line.

```
In [8]: s=np.linspace(0,Strain[4],2)
        y=m*s+b
        FigureB, AxesB = plt.subplots(1, 1);
        AxesB.plot (Strain,Stress,'o'); AxesB.set_xlabel("Strain"); AxesB.set_ylabe
        AxesB.plot(s,y);AxesB.set_xlim(0,.1);AxesB.set_ylim(0,400);
        format_plot(AxesB)
```



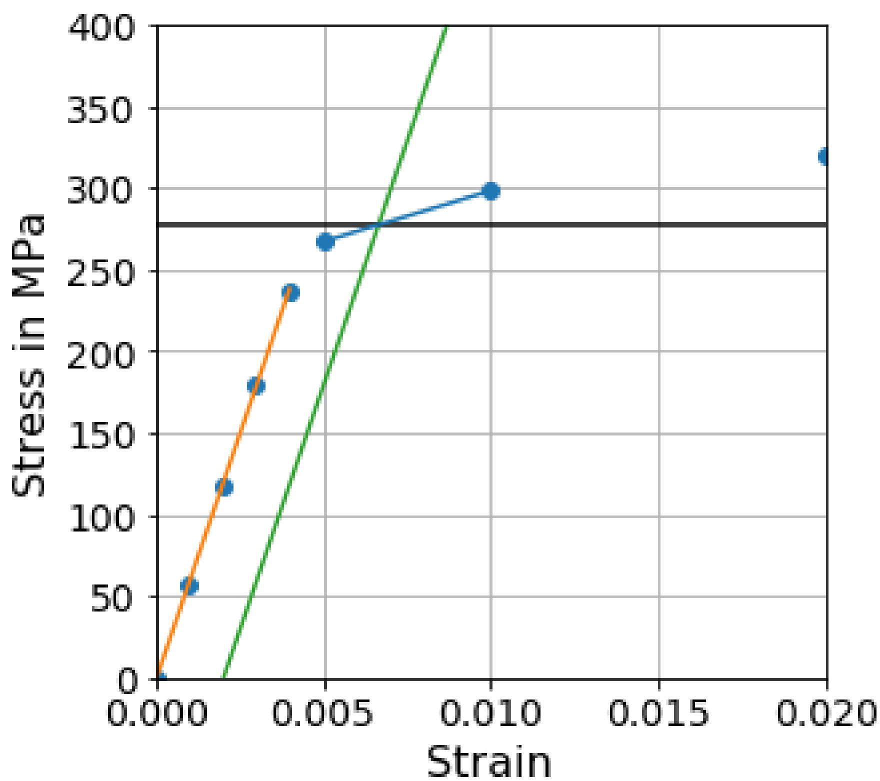
1.4 Determine the yield strength using a strain offset of 0.002

We will graphical determine where a line with an offset of 0.002 intercepts the data.

```
In [9]: offset=0.002
        σ_ys=278; ss=np.linspace(0,0.01,2)
        yy=m*ss+b
        AxesB.plot(ss+offset,yy);AxesB.set_xlim(0,.02);AxesB.set_ylim(0,400);
        AxesB.axhline(σ_ys,c='k');
        AxesB.add_line(matplotlib.lines.Line2D(Strain[5:7],Stress[5:7]));
        print("The yield strength is {:.0f}.".format(σ_ys))
        FigureB
```

```
The yield strength is 278.
```

```
Out[9]:
```



1.5 Determine the ultimate tensile strength of this alloy

This is the maximum value of the stress.

```
In [10]: print("The ultimate tensile strength is {:.0f} MPa".format(Stress.max()))
```

```
The ultimate tensile strength is 369 MPa
```

1.6 Determine the ductility in percent elongation

This is the maximum of the strain.

```
In [11]: print("The strain at fracture is {:.3f}".format(Strain.max()))
```

```
The strain at fracture is 0.165
```

1.7 Compute the modulus of resilience

The modulus of resilience is the area under the curve of the stress - stain plot. The code below calculates that area by approximating that area as rectangles.

```
In [12]: a=Strain[0:len(Data.index)-1]; b=Strain[1:len(Data.index)];Δϵ=b-a;
         a=Stress[0:len(Data.index)-1]; b=Stress[1:len(Data.index)]; h=(a+b)/2;
         area=Δϵ*h;
         print('The modulus of resilience is {:.1f} MPa'.format(area.sum()))
```

```
The modulus of resilience is 55.9 MPa
```

The plot below shows the stress stain curve with the area calculation rectangles.

```
In [13]: MyAxes.bar(Strain[0:len(Strain)-1]+Δϵ/2, h, Δϵ, alpha=0.2, color='b'); MyF
```

```
Out[13]:
```