Lab Notebook

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Fall Semester, 2018

METC 143

Lab 1: Miller Indices

Date: 12/2/18

Summary:

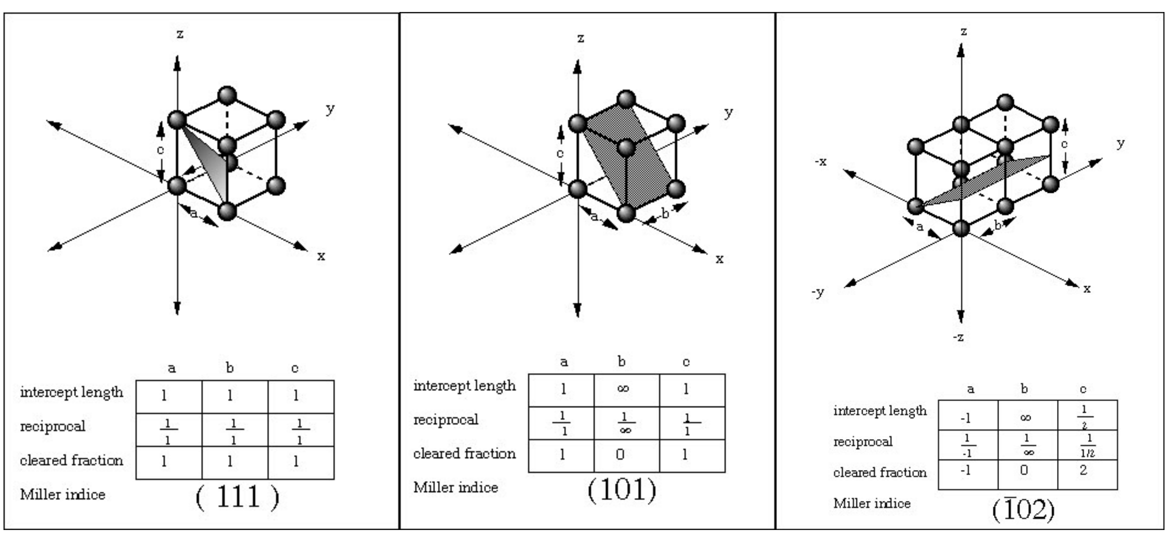
Miller indices are the symbolic vector representation for the orientation of an atomic plane in a crystal lattice and are defined as the reciprocals of the fractional intercepts which the plane makes with the crystallographic axis. The directions and planes are used to specify the structures of lattices and crystals. The number of indices will match the number of dimensions of the lattice or crystal.

History:

The first to introduce indices to denote a crystal plane was C.S. Weiss. His notation was modified independently by his student F.E. Neumann and W. Whewell, whose indices are the inverse of the Weiss indices. These indices were used in a book by Whewell's student—and successor—W. H. Miller, in 1839, *A Treatise on Crystallography.*

Purpose:

The indices are used by identifying the orientation of a crystal face or plane of atoms within a crystal lattice. The Miller indices use a three-integer set to identify a plane. The system uses the format "(abc)" where "a" is the reciprocal of the x-axis intercept, "b" is the reciprocal of the y-axis intercept, and "c" is the reciprocal of the z-axis intercept. If the intercept of an axis is infinity, the result would be the reciprocal of infinity, which is zero. A negative axis intercept is shown as a bar over the integer for that number.



Lab 1: Miller Indices cont.

Referenced:

http://clay.uga.edu/courses/8550/millerindices.html

https://web.iit.edu/sites/web/files/departments/academic-affairs/academic-resource-center/pdfs/Miller_Indices.pdf

http://reference.iucr.org/dictionary/Miller_indices

Lab 2: Safety Factor

Date: 12/2/18

Purpose:

1) Find the safety factor of the hoisting system for lifting CNC machines.
2) Find the diameter of cable needed to give the hoist from question 1, a safety factor of 4
3) Find the material strength of a bottle jack, given the safety factor, rod diameter, and largest expected load.
4) Based on the material strength needed for the bottle jack, decide to use either 1050-H14 aluminum, or 1045 steel.
5) For the material that was not used for the bottle jack, find the rod diameter needed to allow the use of said material.

Procedure:

Using the data given, calculate the requested information.

Results:

1.] Given

CABLE:

$\varnothing = 0.5"$

$S_m = 183674$ psi

FORCE:

$L = 24000$ lbs

$S_F = ?$

$S_F = \frac{S_m}{\sigma}$ $\sigma = \frac{L}{A}$

$A = \pi r^2$

$\varnothing = 2r$

$S_F = \frac{S_m}{\sigma}$ $r = \frac{1}{2}\varnothing = \frac{1}{2}(0.5) = 0.25" = r$

$A = \pi r^2 = \pi \cdot (0.25^2) = 0.19635"^2 = A$

$\sigma = \frac{L}{A} = 24000/0.19635"^2 = 122,230.996$ psi $= \sigma$

$S_F = \frac{S_m}{\sigma} = 183674$ psi $/ 122230.996$ psi $= 1.503 = S_F$

1.) $S_F = 1.5$

Lab 2: Safety Factor cont.

2.

$S_m = 183674\,psi$ $\quad \varnothing = ?$

$L = 24000\,lbs$

$S_F = 4$

$S_F = \frac{S_m}{\sigma}$ $\quad \sigma = L/A$

$A = \pi r^2$

$\varnothing = 2r$

$S_F = \frac{S_m}{\sigma} \rightarrow \sigma = \frac{S_m}{S_F} \rightarrow \frac{L}{A} = \frac{S_m}{S_F}$; $L \cdot S_F = A \cdot S_m$; $A = \frac{L\, S_F}{S_m}$

$\pi r^2 = \frac{L \cdot S_F}{S_m}$; $r^2 = \frac{L \cdot S_F}{S_m \cdot \pi}$; $r = \sqrt{(S_F \cdot L)/(S_m \cdot \pi)}$

$r = \sqrt{\frac{S_F \cdot L}{S_m \cdot \pi}} = \sqrt{\frac{(4) \times (24000)}{(183674) \times (3.14)}} = \sqrt{\frac{96000}{576736.36}} = 0.40798758\,75 = r$

$\varnothing = 2r = 2(0.4079875875) = 0.8159751751 = 0.82" = \varnothing$

2.) $\varnothing = 0.82"$; rounded $= 7/8"\ \varnothing$

3.

Force/LOAD, $L = 17000\,lb$

ROD $\varnothing = 2.5"$

$S_F = 8$

$S_F = \frac{S_m}{\sigma}$ $\quad \sigma = \frac{L}{A}$

$A = \pi r^2$

$\varnothing = 2r$

$S_F = \frac{S_m}{\sigma}$; $\sigma = \frac{S_m}{S_F}$; $\frac{L}{A} = \frac{S_m}{S_F}$; $S_m = \frac{L \cdot S_F}{A} = \frac{L \cdot S_F}{\pi r^2} = S_m$

$r = \frac{1}{2}\varnothing = \frac{1}{2}(2.5") = 1.25" = r$

$S_m = \frac{L \cdot S_F}{\pi r^2} = \frac{(17000)(8)}{(3.14)(1.25^2)} = \frac{136000}{4.90625} = 27719.74522\,psi = S_m$

3.) $S_m = 27719.75\,psi$

Lab 2: Safety Factor cont.

4.

$S_{m_{JACK}} = 27719.75_{psi}$

$S_m\,1045 = 45000_{psi}$

$S_m\,1050\text{-}H14 = 14{,}900$

$45000_{psi} > 27719.75_{psi} > 14900_{psi}$

1045 Steel   JACK   1050-H14

4) 1045 STEEL ; 1050-H14 Aluminum is too weak, and would break

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5.

$S_m = 14900_{psi}$ $L = 17000_{lb}$

$S_F = 8$ $\varnothing = ?$

$S_F = \frac{S_m}{\sigma}$ $\sigma = \frac{L}{A}$ $A = \pi r^2$ $\varnothing = 2r$

$r = \sqrt{(S_F \times L)/(S_m \times \pi)}$

$$r = \sqrt{\frac{(S_F)(L)}{(S_m)(\pi)}} = \sqrt{\frac{(8)(17000)}{(14900)(3.14)}} = \sqrt{\frac{136000}{46786}} = \sqrt{2.9064} = 1.7049 = r$$

$$\varnothing = 2r = (2)(1.7049) = 3.4099 = 3.41'' = \varnothing$$

5.) $\varnothing = 3.41''$

Lab 3: Hardness Test Lab

Date: 12/2/18

Hypothesis:

Materials being purchased for use in production are not as hard as specified by the supplier. The 1018 is expected to test less than 71 HRB, and the 4140 is expected to be less than 55 HRC.

Parts:

4140 steel sample

1018 steel sample

Tools:

Mitutoyo Hr-500 hardness tester

Procedure:

Test a sample of each material on the hardness tester

Results:

4140 sample: 51.2 HRC

1018 sample: 62.4 HRB

Conclusion:

1) Given the material hardness specifications, the supplied samples did not meet the required hardness.
2) The first thing I would recommend is that he contact the steel supplier to let them explain why the steel does not meet specification. If the steel supplier does not buy-back the materials and replace them with the correct steels, I would recommend that the Quality Manager tell sourcing to change steel suppliers. If a change in steel suppliers is not possible, I would recommend that he have the steel supplier send samples of other steels, so that an appropriate substitution could be made.

Lab 3: Hardness Test Lab cont.

3) If the parts being produced are critical to structural integrity, I would suggest a shut-down of production. If incorrect surface hardening or through hardening could be a significant liability to the company—liabilities that lead to serious injury or loss of life—than the production line should discontinue production until the liability risk is eliminated. If the parts play a minor structural role, or a secondary support role, I would suggest that production heat the parts with an oxyacetylene torch and quench them. This would harden the parts and would not require the purchase of specialized equipment and would slow production less than a full heat-treatment process. (I cannot answer the problem properly without context, so this is a generic scenario)
4) If the Quality Manager gets a different hardness reading than the previous samples, there are multiple possible sources of error. The first being that the quality manager took the reading too close to the precious test location—the previous indent would be surrounded by a small area of steel that is work-hardened. The second possibility is that the quality manager is not properly trained with the hardness testing machinery. Another is that the steel could have an inconsistent structure, which would not be surprising given that the steel is not meeting the required steel specifications.

Lab 4: Tensile Strength Analysis

Date: 12/2/18

Hypothesis:

Steel is stronger than aluminum

Parts:

Steel test specimen

Aluminum test specimen

Tools:

T9014 Materials Engineering Trainer (or other tensile strength tester)

Procedure:

Insert specimen into the test apparatus. Locate the micrometer, and note the initial micrometer reading. Pump the hydraulic pump until the pressure gauge shows an increase of 200psi. Use the micrometer to measure the distance of travel. Continue increasing pressure and noting change in distance until fracture.

Repeat this process for the remaining sample.

Results:

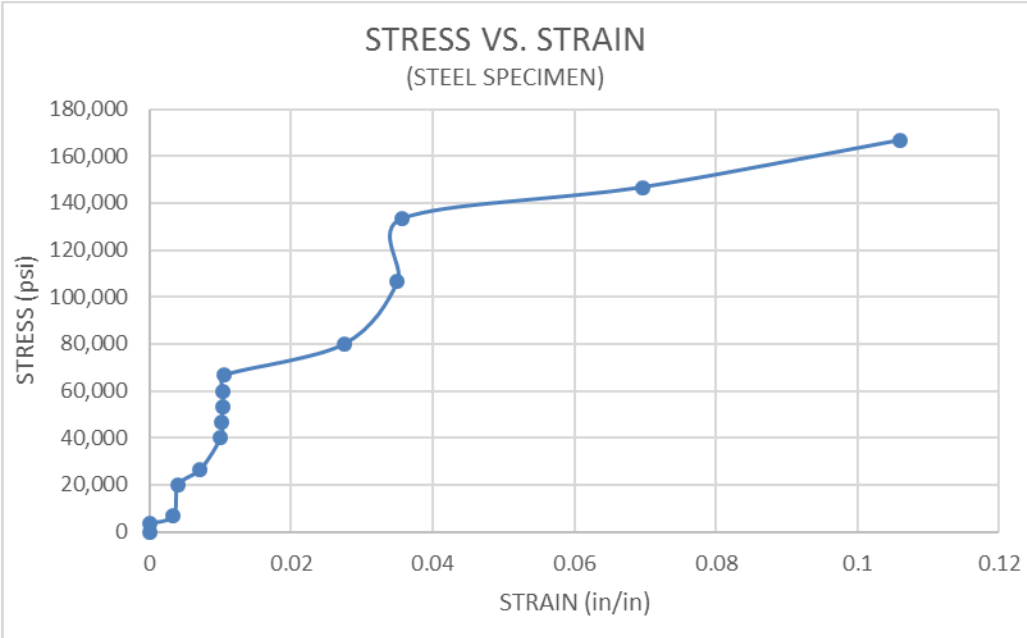
*start on next page

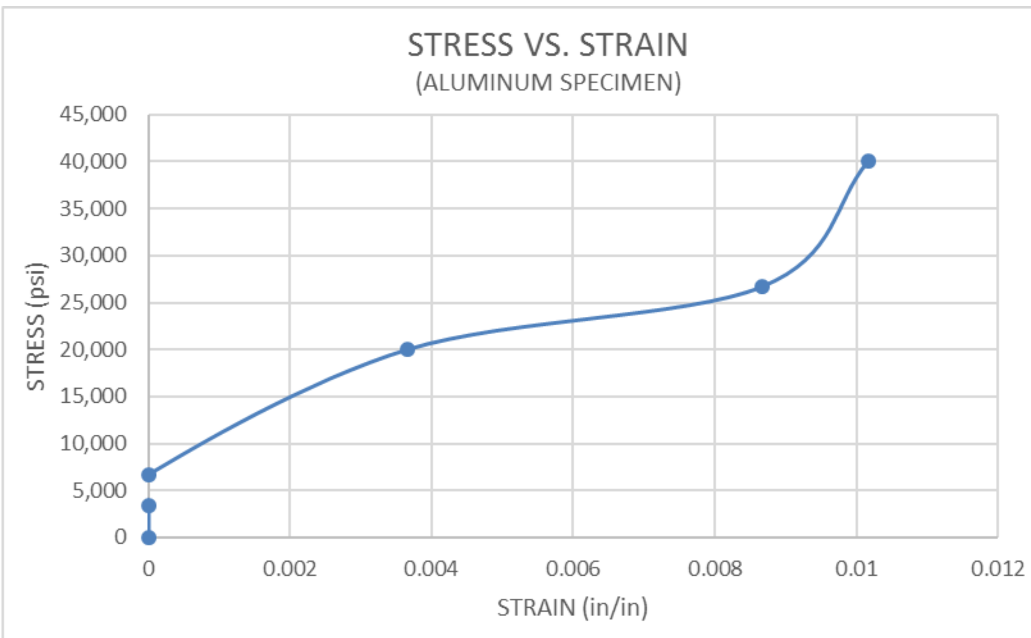
Lab 4: Tensile Strength Analysis cont.

Name	MORGUN WERLING					
Lab No.	4	Date	12/1/2018			
Test Specimen						
Cross Sectional Area (in^2):		**0.015**	**Type: Steel**			
Increment	Pump Pressure (psi)	Cylinder Force (lb)	Micrometer Reading (in)	Gage Length (in)	Stress (psi)	Strain (in/in)
1	0	0	0	3	0.000	0
2	200	50	0	3	3,333.333	0
3	400	100	0.01	3.01	6,666.667	0.003333
4	800	300	0.012	3.012	20,000.000	0.004
5	1000	400	0.0215	3.0215	26,666.667	0.007167
6	1200	600	0.03	3.03	40,000.000	0.01
7	1400	700	0.0305	3.0305	46,666.667	0.010167
8	1600	800	0.0308	3.0308	53,333.333	0.010267
9	1800	900	0.0311	3.0311	60,000.000	0.010367
10	2000	1000	0.0318	3.0318	66,666.667	0.0106
11	2200	1200	0.0825	3.0825	80,000.000	0.0275
12	2400	1600	0.105	3.105	106,666.667	0.035
13	2600	2000	0.107	3.107	133,333.333	0.035667
14	2800	2200	0.209	3.209	146,666.667	0.069667
15	3000	2500	0.318	3.318	166,666.667	0.106
16	3100	Fracture	Fracture			

Name	MORGUN WERLING					
Lab No.	4	Date	12/1/2018			
Test Specimen						
Cross Sectional Area (in^2):		**0.015**	**Type: Aluminum**			
Increment	Pump Pressure (psi)	Cylinder Force (lb)	Micrometer Reading (in)	Gage Length (in)	Stress (psi)	Strain (in/in)
1	0	0	0.001	3	0.000	0
2	200	50	0.001	3	3,333.333	0
3	400	100	0.001	3	6,666.667	0
4	800	300	0.012	3.011	20,000.000	0.003667
5	1000	400	0.027	3.026	26,666.667	0.008667
6	1200	600	0.0315	3.0305	40,000.000	0.010167
7	1300	Fracture	Fracture			

Lab 4: Tensile Strength Analysis cont.





Lab 4: Tensile Strength Analysis cont.

Conclusion:

1.) The hypothesis was correct. The steel sample fractured at slightly over 166,000 psi stress, while the aluminum sample fractured at slightly over 40,000 psi stress. This means the steel used in this test was just over four times the strength of the aluminum.
2.) There are multiple potential sources of error for this lab. The first being the potential for material defects. Another is that the data was simply given to the class, and any fault in procedure would go relatively unnoticed. Another source of error would be the sample size of one for each material.
3.) Steel: AISI 4142 Steel, Quenched and Tempered to 380 HB (ultimate tensile strength of 204,800 psi)
    Aluminum: There is no aluminum alloy that will sustain 167,000 psi stress like the steel tested—except for aluminum matrix composite materials—so the following is an aluminum alloy that would survive the 40,000+psi stress that fractured the aluminum in the lab. 2014-T651 Aluminum (ultimate tensile strength of 60200-70100 psi)