5 tests each machine

LABORATORY EXERCISE #3
ROCKWELL HARDNESS

OBJECTIVES

- Measure the hardness of a brass sample on the Rockwell B scale (HRB) using an analog type hardness tester.
- Measure the hardness of a hardened steel sample on the Rockwell C scale (HRC) using a digital type hardness tester.
- Measure the hardness of a case hardened steel sample on the Rockwell 45N scale (HRN) using a superficial type analog hardness tester.
- Convert Rockwell hardness values to equivalent Brinell hardness values.
- Convert hardness values into estimates for tensile strength values.
- Use your data to solve an applications problem.

PROCEDURES

- Obtain information from the instructor concerning the applied loads and types of indenter tips used for each of the Rockwell scales.
- For each measurement, make sure that there is no dirt on the sample or on the anvil of the tester. Place the samples on the anvils such that the indenters will make contact at locations that are not too near previous measurement points. Previous measurements create localized strain hardening that can distort subsequent readings.
- For the analog type devices, pull the lever back toward you to elevate the weights. Rotate the anvil wheel slowly, elevating the sample until it makes contact with the indenter tip. Continue rotating the wheel until the small needle is aligned with the small black dot. If you go beyond the black dot you must reverse the rotation of the wheel and start over. Rotate the analog dial until the large needle is aligned with the set point. Trip the lever to release the weights. Wait about fifteen seconds to make sure that the forces have stabilized. Pull the lever back toward you to elevate the weights, and then read the Rockwell hardness value from the position of the large needle on the analog dial. Make sure that you are reading the correct Rockwell scale, since some of the dials have multiple scales.
- For the superficial hardness readings, use the chart in the lab to convert HRN values to equivalent HRC values.

- For the digital type device, rotate the anvil wheel slowly until the sample makes contact with the indenter tip. Continue rotating the wheel while observing the row of red lights on the display panel. Stop rotating when the light labeled "set" is illuminated. If you go beyond this point to the light labeled "over", you must reverse the rotation of the wheel and start over. Everything is automatic after "set" is illuminated . . . just stand back and watch. When the light labeled "OK" illuminates, read the Rockwell hardness value on the digital display.

- Obtain five hardness readings for each material. You should expect that the values for each material will be similar, but they will not be constant, i.e., the standard deviations will not be zero.

DATA ANALYSIS

- Create a 99% confidence interval estimate for the mean hardness of the brass on the Rockwell B scale. Use small sample methods (student's "t" distribution).

- Create a 99% confidence interval estimate for the mean hardness of the hardened steel on the Rockwell C scale. Use small sample methods (student's "t" distribution).

- Create a 99% confidence interval estimate for the mean hardness of the case hardened part on the Rockwell C scale. Use small sample methods (student's "t" distribution).

- Use information in your text, or from the web, to convert the mean Rockwell hardness values into equivalent mean Brinell hardness values for each material.

- Use information in your text to convert the mean Brinell hardness values into mean tensile strength values for each material, in MPa.

- Solve the following problem:

    - A load of 5000 kg is to be lifted with a helicopter using a steel cable with a fixed length of 100 m. The maximum stress will be at the top end of the cable, which is supporting the weight of the load as well as the weight of the cable. Create a graph of the maximum stress (MPa) versus the diameter of the cable for $0.5 \text{ cm} \leq d \leq 3.0 \text{ cm}$ using the assumptions shown below. Use a sufficient number of points to create a smooth graph with linear scales . . . a scatterplot.

        - The cross sectional area of the steel equals 91% of the cross sectional area of the cable.

        - The density of the steel is 8.0 g/cm^3.

        - Assume that the steel has the mean Rockwell hardness of the hardened steel that you measured in this exercise. Use your graph to determine the minimum diameter of the cable such that the maximum stress at the top end equals half of the tensile strength of the material.

REPORT

Write a short format lab report that includes the following elements:

- A brief statement of the objectives of the exercise.
- A brief description of the procedures used to measure the Rockwell hardness values.
- A table summarizing the loads and indenter tips for the three Rockwell scales used in this exercise.
- A table summarizing the HRB, HRC and HRN data values that you measured.
- A table summarizing the confidence intervals for the hardness of each material.
- A table summarizing the mean values for HRB, HRC, HB, and tensile strength, as appropriate, for each material.
- A graph showing maximum stress (MPa) versus cable diameter (cm) for the problem posed in the data analysis section, above. Supply a description of the problem before presenting the graph. Otherwise the graph will have no meaning to the reader.
- A brief summary of the results of this exercise, including your solution for the minimum acceptable diameter of the cable.
- An appendix containing the calculations for the three confidence intervals.
- An appendix containing the calculations for the cable stress problem posed in the data analysis section, above.