King Fahd University of Petroleum & Minerals
Mechanical Engineering Department

ME 578: Mechanical Properties of Engineering Polymers

Semester (201)

Homework # 2

Assigned on: 1/10/2020

Due date: 11/10/2020

Kindly, use this page as a cover page for your HW

Name: ______________________________ ID #: ______________________

#	Marks	Grades
1	20	
2	25	
3	15	
4	15	
5	25	
Total	**100**	

Problem 1 (20 points):

A flexible rubber pipe is formed from an ideal rubber with tensile modulus $E = 1.5$ MPa. The external pipe diameter initially is 20 mm and the wall thickness is 3 mm. It is filled with a fluid pressurized to 50 kPa. Find the new pipe diameter and wall thickness. Assume the axial component of internal pressure is carried by rigid pipe connectors: the pipe itself therefore carries no axial stress. (You will find this problem has no analytical solution. Use either a graphical method or numerical method (with microcomputer or programmable calculator) to obtain the solution.)

Problem 2 (25 points):

A sample of a certain ideal rubber has a number average Mn between crosslinks of [illegible] and a density of [illegible]. A block of this rubber, a cube of side [illegible] mm, is tested at a temperature of [illegible] K. What is its tensile modulus? What is its shear modulus? Axes X, Y, and Z are chosen parallel to the edges of the cube. A compressive force F_x is applied in the X-direction to reduce the X dimension from [illegible] mm to [illegible] mm. Calculate F_x. What do the Y and Z dimensions become? A further compressive force F_y is now applied in the Y-direction to reduce the Y-dimension to [illegible] mm, the X-dimension remaining at [illegible] mm. What now are the magnitudes of the forces F_x and F_y? What has the Z-dimension now become? How much strain energy is now stored in the block? Assume [illegible]

Problem 3 (15 points):

A sample of crosslinked natural rubber (polyisoprene) is found to have shear modulus $G =$ [illegible] kPa at [illegible]. Calculate N, the number of subchains between crosslinks per m^3 and hence the number average degree of polymerization between crosslinks.

Problem 4 (15 points):

For a certain rubber, it was found by experiment that in uniaxial extension by up to 100% the strain energy function was accurately given by the Mooney equation, with $C_1 = 300$ kPa and $C_2 = 100$ kPa. Find the tensile stress, based on the original cross- sectional area, required to extend a bar of this rubber by 100%. If an approximate prediction of this stress is obtained by applying the Gaussian approximation to this material, find the magnitude of the error which results.

Problem 5 (25 points):

The following are the first seven data points on the graph of Figure 1

λ	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
σ (kPa)	0	[illegible]	220	308	[illegible]	[illegible]	[illegible]

(1) Show that the Mooney theory would predict a linear relation between [illegible] and [illegible]. Make a plot that shows the data satisfy the theory and find the constants C_1 and C_2, and hence the shear modulus G.

(2) Apply the equation $G = NkT$ to find the number average degree of polymerization between crosslinks for this sample of natural rubber.

(3) Look again at Figure 1 and estimate the number of chain links in the subchain between crosslinks and hence estimate the number of [illegible] units that constitute one link.

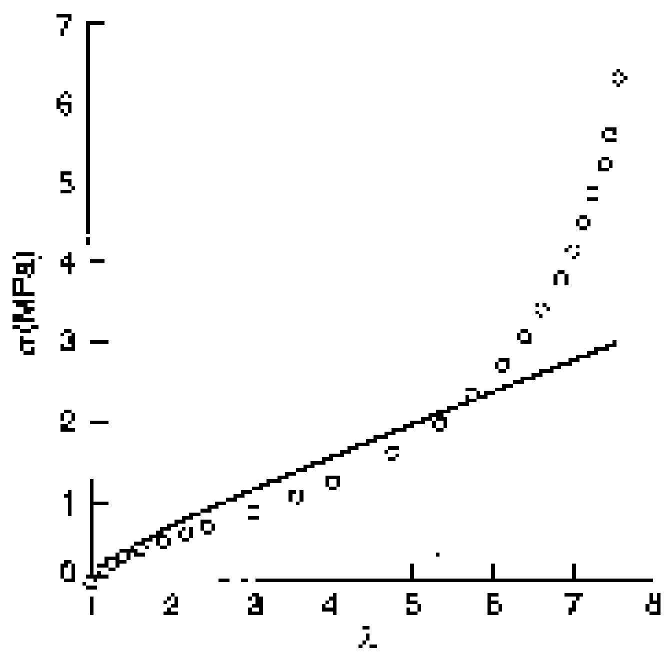

Figure 1: Nominal stress versus extension ratio, for uniaxial stretching of a sample of crosslinked natural rubber. Full line shows the Gaussian prediction.