EVERYDAY EXAMPLES OF ENGINEERING CONCEPTS

S11: 2D stress systems

This is an extract from 'Real Life Examples in Mechanics of Solids: Lesson plans and solutions' edited by Eann A. Patterson, first published in 2006 (ISBN:978-0-615-20394-2) which can be obtained on-line at www.engineeringexamples.org and contains suggested exemplars within lesson plans for Sophomore Solids Courses. Prepared as part of the NSF-supported project (#0431756) entitled: "Enhancing Diversity in the Undergraduate Mechanical Engineering Population through Curriculum Change".

INTRODUCTION

(from *'Real Life Examples in Mechanics of Solids: Lesson plans and solutions'*)

These notes are designed to enhance the teaching of a sophomore course in mechanics of solids, increase the accessibility of the principles and raise the appeal of the subject to students from a diverse background[1]. The notes have been prepared as skeletal lesson plans using the principle of the 5Es: Engage, Explore, Explain, Elaborate and Evaluate. These are not original and were developed by the Biological Sciences Curriculum Study[2] in the 1980s from work by Atkin and Karplus[3] in 1962. Today they are considered to form part of the constructivist learning theory and a number of websites provide easy to follow explanations of them[4].

These notes are intended to be used by instructors and are written in a style that addresses the instructor, however this is not intended to exclude students who should find the notes and examples interesting, stimulating and hopefully illuminating, particularly when their instructor is not utilizing them. In the interest of brevity and clarity of presentation, standard derivations and definitions are not included since these are readily available in textbooks which these notes are not intended to replace but rather to supplement. Similarly, it is anticipated that these lessons plans can be used to generate lectures/lessons that supplement those covering the fundamentals of each topic.

Acknowledgements

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[1] Patterson, E.A., Campbell, P.B., Busch-Vishniac, I., Guillaume, D.W., 2011, The effect of context on student engagement in engineering, *European J. Engng Education*, 36(3):211-224.
[2] http://www.bscs.org/library/BSCS_5E_Instructional_Approach_July_06.pdf
[3] Atkin, J. M. and Karplus, R. (1962). Discovery of invention? *Science Teacher* 29(5): 45.
[4] e.g. http://www.science.org.au/primaryconnections/constructivist.htm

TWO DIMENSIONAL STRESS SYSTEMS

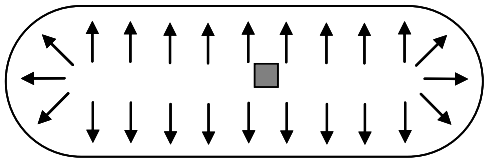
11. Principle: **Mohr's circle of stress**

Engage:

Use a hot plate in the classroom to fry some sausages and share with the class. Find a brand of high quality sausages that will not come undone at the ends and do not pierce them so that they burst longitudinally while cooking.

Explore:

Before they eat; ask students to examine the splits in the sausages. Discuss what direction the maximum stress must be acting to cause the damage seen in sausage skins.

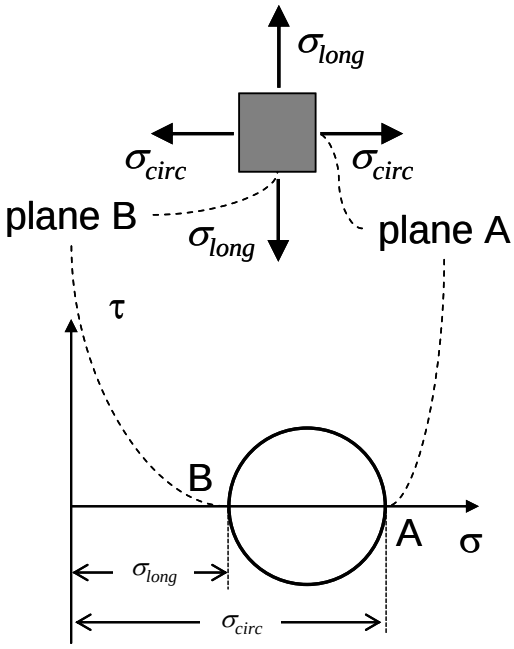


Explain:

Discuss the derivation performed earlier in the course to obtain expressions for longitudinal and circumferential stresses in a cylindrical pressure vessel:

$$\sigma_{circ} = \frac{pr}{t} \text{ and } \sigma_{long} = \frac{pr}{2t}$$

And hence explain longitudinal split due to circumferential stresses.



Elaborate

Discuss that there are two stresses acting in perpendicular directions so that an element aligned to these directions experiences the stresses as shown. Then construct the Mohr's circle of stresses and explain how it is the loci of points representing planes at all orientations in the wall of the sausage.

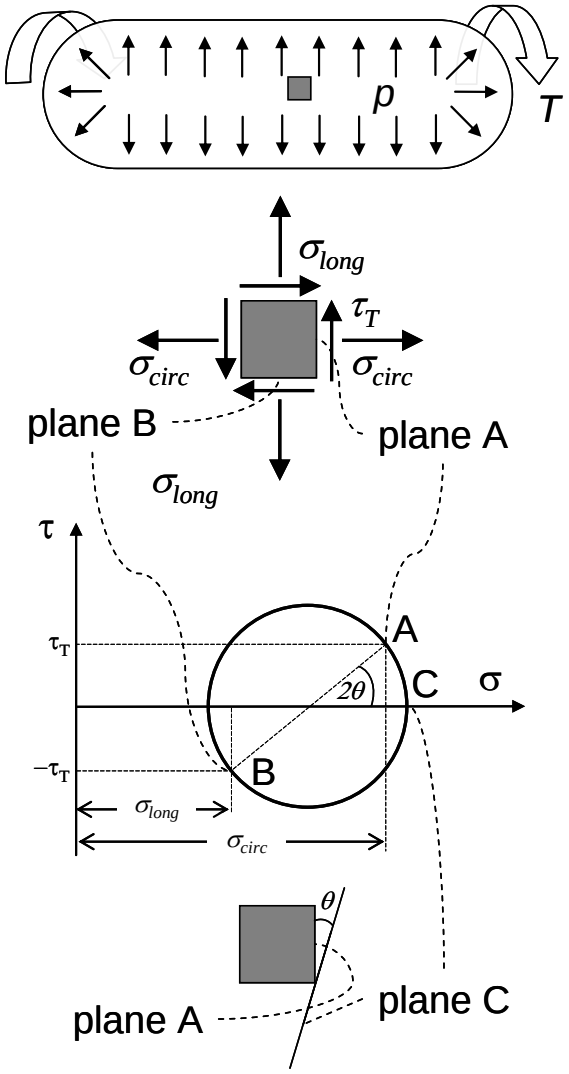
Evaluate

Ask students to attempt the following examples:

Example 11.1:

How does the Mohr's circle change for the sausage if there is some residual stress from twisting the sausage during manufacture? Where would you expect the sausage to split now?

Solution:



i.e. at an angle $((\pi/2)-\theta)$ to the longitudinal axis.

Example 11.2

Ask students to look for two other examples in their everyday life and explain how the above principles apply to each example.