Engineering Ethics Cases with Numerical Problems

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Chemical Engineering Case 4

Chateau La Bomb

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Suggested Courses:

Mass & Energy Balances, Thermodynamics

Level:

Sophomore, Junior & Senior

I. Narrative

For an evening celebration, Allison S. Smith, a resident of Hothouse, Georgia, purchased a bottle of champagne from her local Wiggly Pig grocery store on a hot summer day. Before she went home, she stopped at several stores to run some errands. The bottle sat on the back seat of her closed car at each of her stops.

Upon arriving home she removed the wire cage surrounding the cork to open the bottle of champagne. Upon removing the protective cage, the cork exploded out of the bottle and hit her in the eye. Despite the best efforts of her doctors, she lost sight in that eye.

Allison, suspecting that the bottle/cork assembly was improperly designed and constructed, contacts the firm of Randall, Unger, Thomas, Harris, Lawton, Edgar, Sanders, & Stone to represent her in a product liability case against Pepe Lepue vintners, Big Green bottling company, and Plug It cork company. Their claim is that the bottle and cork assembly were improperly designed to withstand the pressure in the bottle.

The law firm contacts you to perform an engineering analysis to support this claim.

II. Numerical and Design Problems

Problem 1.

Calculate the internal pressure in the bottle under the conditions present when Allison removed the metal cage. State your assumptions. A key parameter will be the gas head space. Justify fully your estimate of this volume. Determine whether the pressure is within the standards set for internal pressure strength for glass bottles for carbonated beverages.

Problem 2.

Assuming that the bottle was designed such that the cork would blow out before the bottle bursts, what pressure would the cork be expected to resist? For this problem, the cork will be removed from the bottle when the friction force between the cork and wall and the force necessary to compress the cork to the bottle opening diameter are overcome. Propose additional experiments to quantify the pressure required to expel the cork.

III. Questions on Ethics and Professionalism

1. There are several models for professional engineering responsability:

Malpractice Model: to exercise little or no care

Due-Care Model: to take reasonable precautions/care

Good Works Model: to go above and beyond the call of duty

In your view, which of these models of professoinal responsibility apply to the champagne bottle design currently used by Pepe, by Big Green, and by Plug it? Propose other designs to fit the other two models of professional responsibility.

2. Estimate the cost of implementing the design changes presented above. Discuss the benefits to Lepue and the public of implementing these changes. Assume that Pepe Lepue sells 250,000 bottles of champagne per year. The company reports that on average, they spend $65,000 per year litigating and settling liability suits related to cork injuries. Based on your estimates would the benefits associated with your proposed design changes outweigh their associated costs.

3. Discuss the cost and benefits of improving the product safety. Do you think that design and manufacturing changes are required if 1 injury loss per year occurs? How would your answer change if 1,000 or 10,000 injury losses per year were documented?

4. One issue in this case is the temperature of the champagne in the bottle when it was opened. If the champagne bottle was warm, the pressure in the bottle would be significantly elevated. Since the bottle sat in a warm car while Allison ran several errands, was she acting responsibly in opening a warm bottle?

IV. Data for this problem

1. Champagne bottles are filled to 4-5 atm CO_2 pressure at 20C.

2. During fermentation of genuine champagne, the pressure in the bottle often exceeds 90 psig and leads to exploding bottles. However, this says nothing about the type of bottle or its internal pressure burst strength.

3. The U. S. Department of Commerce/NIST Voluntary Product Standard PS 73-89 "Glass Bottles for Carbonated Soft Drinks" requires that nonrefillable (softdrink) bottles shall withstand a minimum internal pressure of 200 psig.

4. Solubility of CO_2 in water (from Perry's)

T (C)	Solubility (g/100 cm^3 sat'd soln)	T (C)	Solubility (g/100 g H_2O)
	(1 atm)		(25 atm)
0	0.3346		
10	0.2318	18	3.86
20	0.1688	31.04	2.80
30	0.1257	35	2.56
40	0.0973	40	2.30
50	0.0761	50	1.92
60	0.0576		
75	1.35		
100	0		

Alternatively, Henry's law may be useful.

$p_A = H_A x_A$

Where H_A is in atm/mole fraction

T (C)	H_A (atm/mole fraction)
0	728
10	1040
20	1042
25	1640
30	1860
40	2330

(From L. J. Thibodeaux, Chemodynamics: Environmental Movement of Chemicals in Air, Water, and Soil, J. Wiley and Sons, New York, 1977, p. 452. adapted from National Research Council, *International Critical Tables, Vol. III,* McGraw-Hill, New York, 1929.

Solutions

Problem 1.

See attached.

Problem 2.

For the cork to be removed, it must slide out the neck of the bottle and be compressed such that its diameter is equal to the bottle diameter. Thus, this problem requires that the students estimate the coefficient of friction from correlations in handbooks. Reasonable estimates of the cork geometry and tabulated data on the compressibility of cork are also available. Alternatively, students might assume that Allison bought a less expensive brand with a plastic cork. Here, a reasonable value for the coefficient of friction would suffice.