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Home Experiments to enhance student experiential learning in Mechanical Engineering

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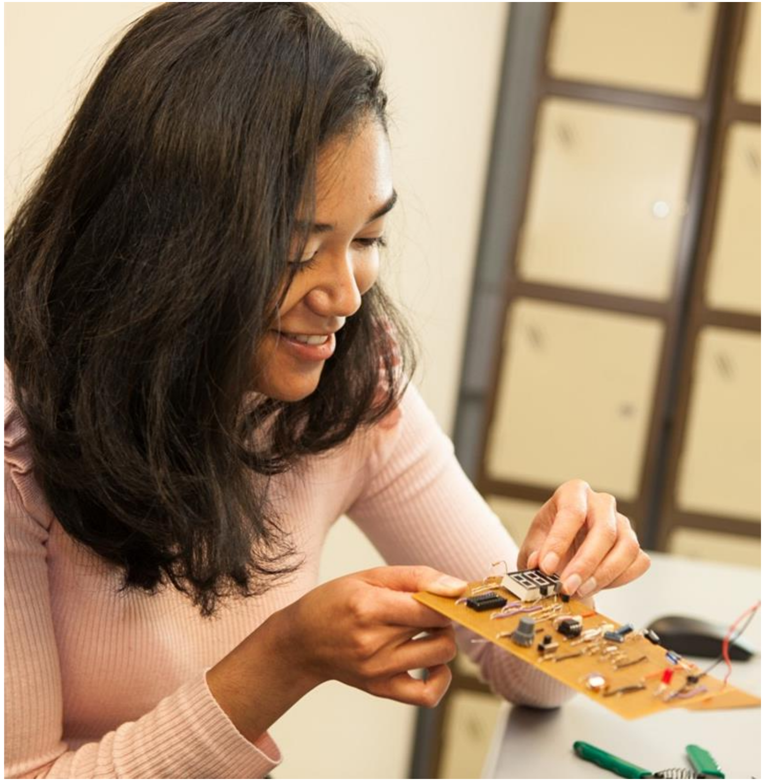

Introduction

This presentation discusses two home experiments devised for year 4 students in Mechanical Engineering, one in analysing a fin for heat transfer, the other to investigate corrosion behaviour of metals using simple materials and common household chemicals.

In the UDL redesign task, I noted "some aspects of course work can be formulaic, even in practical laboratory classes"

"engineering does not assign learning to stand-alone subject areas" and that engineers use subject knowledge, understanding and other skills along with tools to solve problems (Katehi et al., 2009).

Introduction

Wanted to encourage investigation of knowledge rather than retransmission via a report. This also provided another method of engagement in addition to labs and lectures which may suit the more independent learner type."

To increase student involvement..

- introduced simple home experiments for both Modules.
- hoped to encourage self-led investigation and observation of phenomena which draws parallels between the physical and theoretical aspects.

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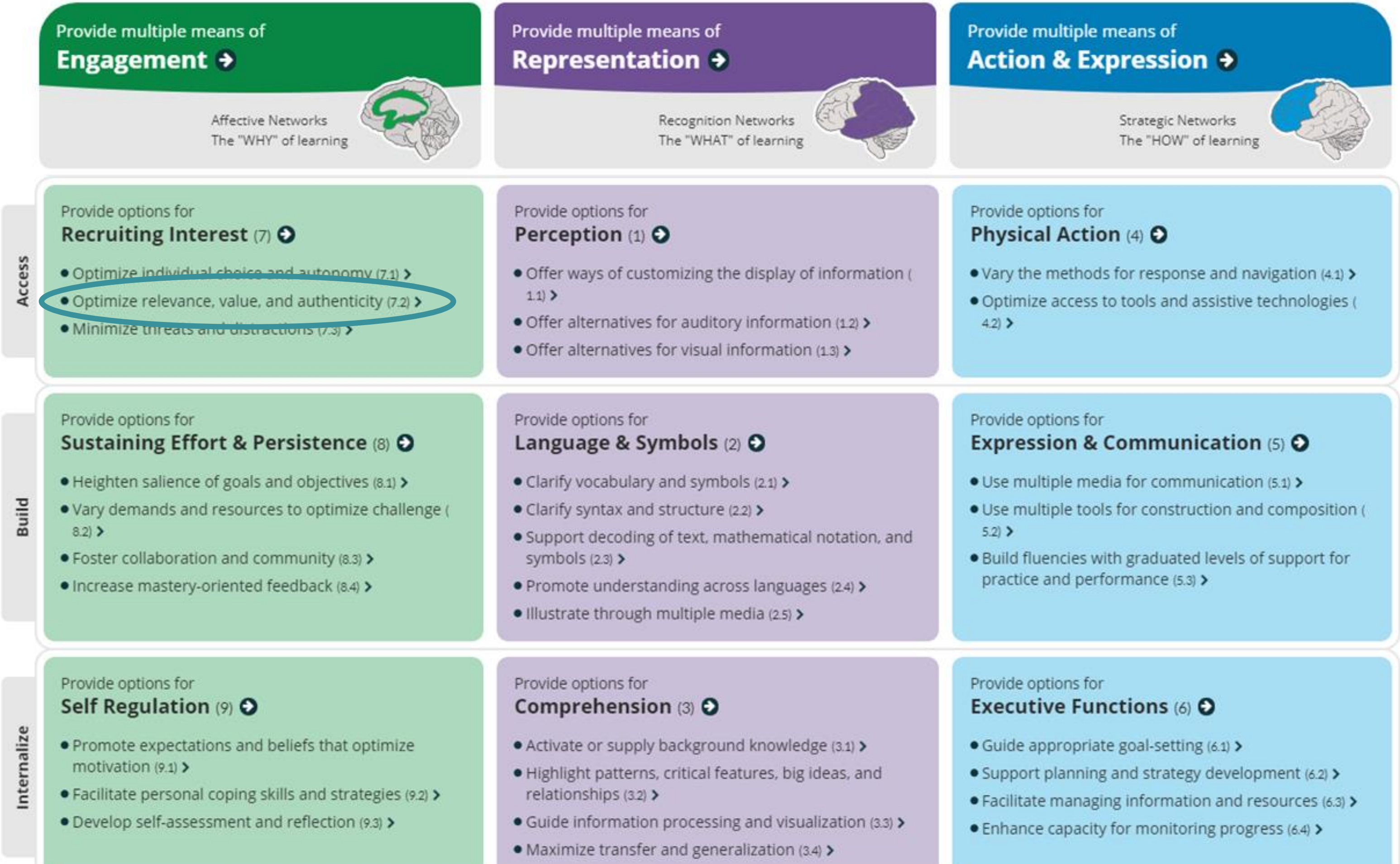
Position within UDL Framework



UDL Rationale

https://udlguidelines.cast.org/engagement/recruiting-interest/relevance-value-authenticity

…Individuals are engaged by information and activities that are relevant and valuable to their interests and goals. This does not necessarily mean that the situation has to be equivalent to real life, as fiction can be just as engaging to learners as non-fiction, but it does have to be relevant and authentic to learners' individual goals and the instructional goals. Individuals are rarely interested in information and activities that have no relevance or value…..

Optimize relevance, value, and authenticity

…..demonstrate that relevance through authentic, meaningful activities………

UDL Rationale

Variety of student tasks.

In classroom delivered modules, students accustomed to continual assessment exercises in conventional forms, i.e. lab reports, mock exams.

I investigated introduction of more self-led investigative learning in two modules with these home based experiments on (i) stress corrosion and (ii) effectiveness of cooling fins.

- I had previous student experience of a stress corrosion test where this was now going to be a topic in Engineering Materials Analysis.
- A Google search provided several simple options for Thermodynamics and heat transfer, one of which was fins, the theory behind which can be complex to grasp.

Basis of the experiments

1

Home Experiments in Mechanical Engineering

Latif M. Jiji, Feridun Delale and Benjamin Liaw
The City College of The City University of New York

Abstract

This paper describes 14 experiments in mechanical Engineering which students can perform at home using readily available supplies. The experiments are designed for integration with lecture courses in thermodynamics, fluid flow, heat transfer and solid mechanics. hey represent applications of theoretical concepts taught in mechanical engineering, In each experiment theoretical predictions are compared with experimentally obtained results. Although crude measuring techniques are used at home, comparison between theoretical and experimental results is usually satisfactory.

A key feature of the experiments is that they are simple and easy to carry out, requiring approximately one hour to perform. Aside from enhancing students' comprehension of theoretical concepts, they provide opportunities for hands-on experience-, encourage resourcefulness and raise questions about accuracy, approximations, assumptions and modeling. Experience with home experiment assignments at the City College has demonstrated their utility as an effective learning tool. In general students enjoy doing the experiments and view them as a welcomed departure from traditional assignments.

I. Introduction and Previous Studies

The idea of performing hands-on experiments using simple, inexpensive and readily available supplies has long been adopted extensively in high school and college science courses [1-5]. The practice usually involves a careful coordination of experiments with theoretical principles central in the course. Its main goal is to address the important question: "How to simplify, approximate and model a complicated, physical phenomenon into a theory and what is the error induced during the process of idealization?" Recently, this pedagogy has also been introduced into engineering courses. Regan et al. [6] described four laboratory experiments using edible materials. In an attempt to construct an efficient curriculum, Giorgetti [7] combined theory and laboratory experiment into a single course on fluid mechanics. Dvorak [8] discussed integration

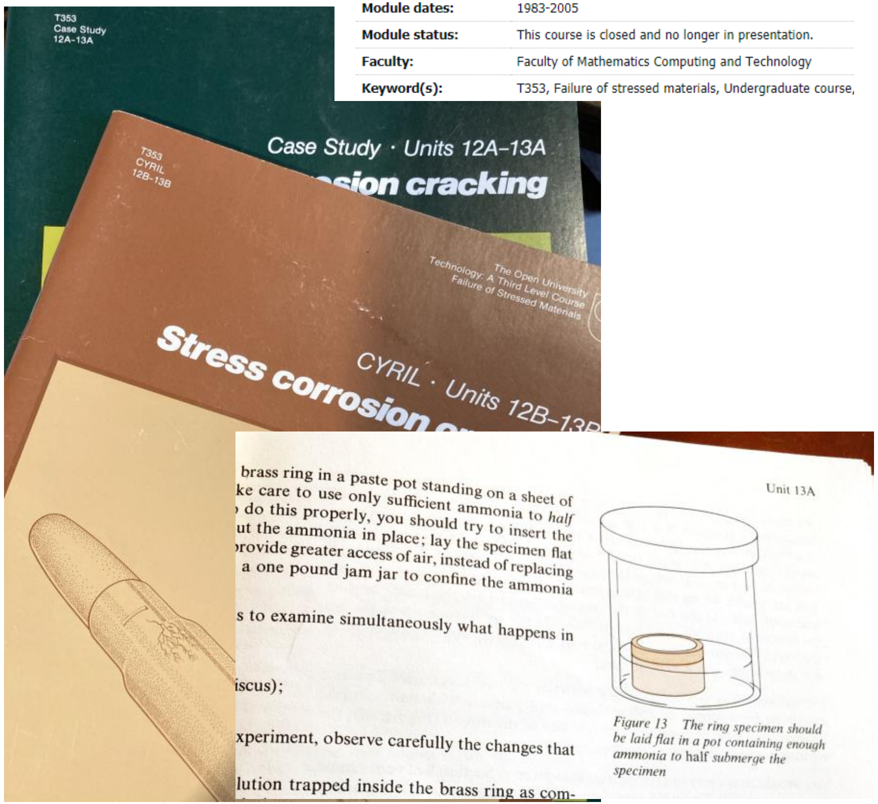
Jiji, L. M., & Liaw, B., & Delale, F. (1996, June), Home Experiments In Mechanical Engineering Paper presented at 1996 Annual Conference, Washington, District of Columbia. 10.18260/1-2--6085

2

The Open University

T353 Failure of stressed materials

Title:	Failure of stressed materials
Module code:	T353
Module dates:	1983-2005
Module status:	This course is closed and no longer in presentation.
Faculty:	Faculty of Mathematics Computing and Technology
Keyword(s):	T353, Failure of stressed materials, Undergraduate course,



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Preparation of Materials

1

2

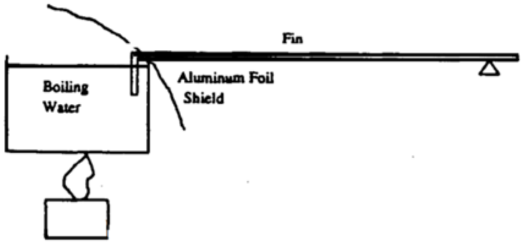
Acknowledge assistance of Technical Staff in Faculty of Engineering and Design to source and prepare these at short notice.

Guidelines for experiments

Thermodynamics Assignment Home Experiment (20%)

C. Heat Transfer

C1 Constant area fin: Fill a pot to the rim with water and bring it to boil. Cut a 35 cm long section from a metal wire-hanger. Bend a 5 cm section at one end and immerse it in the boiling water. Support the wire in the horizontal position as shown. Use aluminum foil to shield the wire from the heating element or the flame of the stove. Determine the distance from the boiling water along the wire where the temperature drops to 37°C (body temperature). Compare the result with theoretical prediction using fin solution.



Results: Home experiment: distance from base =4.5 cm
Fin theory: distance from base = 7.3 cm
Error = 38.4%

Using the supplied Aluminium and Mild Steel sections, perform the above experiment at home. You can also try with a coat hanger as described above.

$$\dot{Q}_{\text{long fin}} = -kA_c \left.\frac{dT}{dx}\right|_{x=0} = \sqrt{hpkA_c}\,(T_b - T_\infty)$$

First perform experiment and note L where t= 37 degrees.

Then estimate h for top and bottom surfaces of fin

Submission date

22nd Dec 2020

Guidelines for experiments

Guidelines for Home Experiment

Stress Corrosion of Brass rings

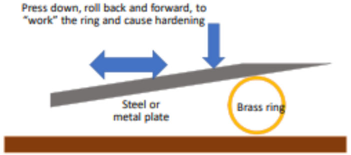
Equipment Needed

1. 4 brass rings
2. Clean jam jar or two, with lid
3. Household ammonia
4. Rubber gloves,
5. rag or tissue paper



Method

1. Take 4 brass rings
2. Work harden two, to set up residual stresses, either tighten them carefully in a joint, or carefully bend and rebend without cracking using pliers or the method shown in the figure.
3. Anneal the other two rings (hold over flame or stove till barely red colour or near it) to relieve any internal stresses. Be careful at this stage not to injure yourself, or others.
4. Mark the annealed and hardened rings. Place 1 annealed and 1 hardened ring in the jam jar with a rag (tissue paper) and add around 10-20ml of Ammonia, enough to make the base and tissue very moist.
5. Place the other two out of the way, mark the annealed and hardened rings.
6. Set up a log, Record start date and time.
7. Inspect every few days, note any changes,
8. After 3 weeks test all 4 rings.
9. Record the results and post to Moodle
10. Write up experiment, try to photograph where possible.



NB!

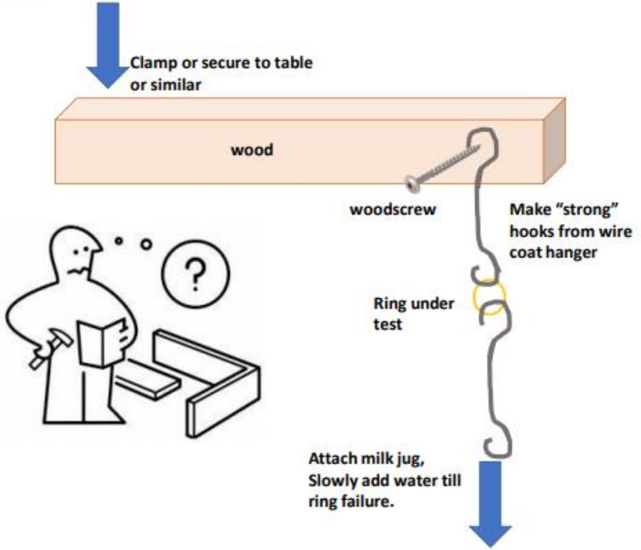
Ammonia while an accepted chemical at household dilutions, is toxic and a severe irritant. Don't mix with bleach or other household chemicals and keep well away from children and curious persons. Used correctly the leftover ammonia can be a useful cleaner around the house.

Testing

Equipment Needed

1. the 4 marked rings
2. Milk jar, leave handle, other section can be partly cut away to allow easy filling
3. Coat hangers
4. Misc wood and screws / clamps



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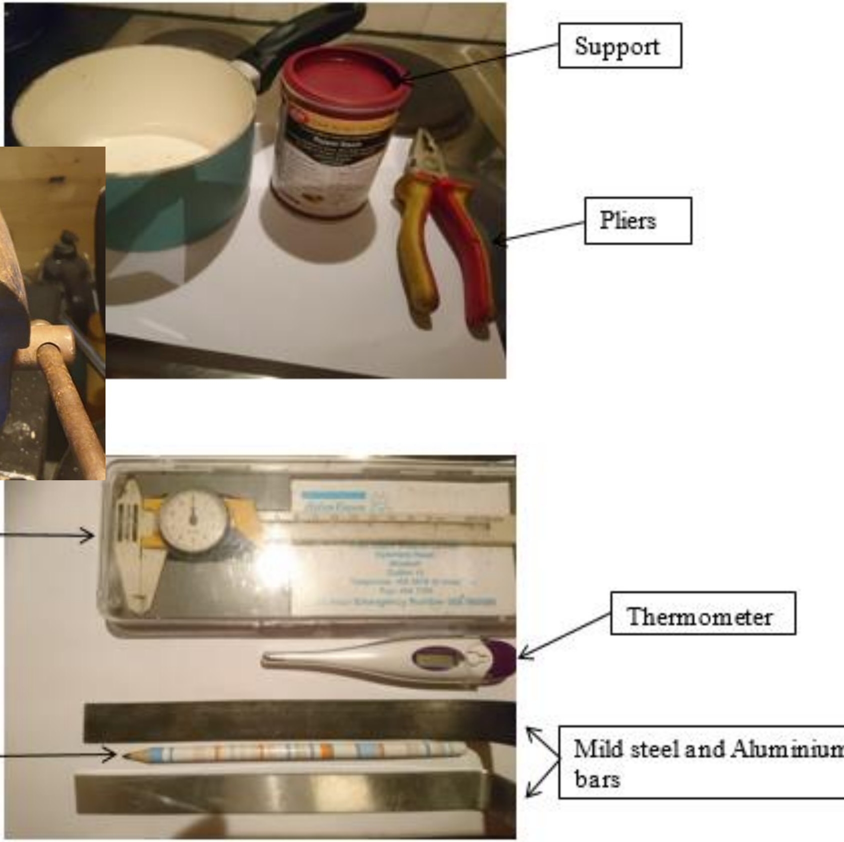
Task (1) Thermodynamics

Heat Transfer in Fin

They prepared



Task (1)

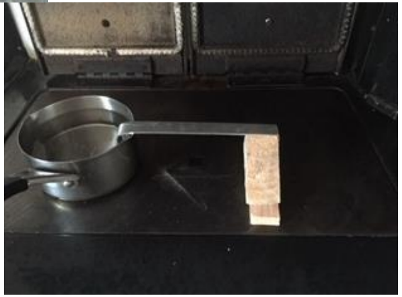
Thermodynami

They heated

Heat Transfer in Fin

Figure 4: Experimental setup for mild steel.

Figure 5: Experimental setup for Aluminium.



Task (1) Thermodynamics

Heat Transfer in Fin

They measured

Temperature reading from aluminium. Thermometer topped out at 43°C at the tip of the aluminium (Reading Hi)

Thermometer at location where the temperature is at 37°C on the mild steel fin

Task (1) Thermodynamics

Heat Transfer in Fin

They reported

$\dot{Q}$ Long fin $= \sqrt{(10.298)(0.44)(50.2)(4\times10^{-4})}\ (37-20)$

$\dot{Q}$ Long fin $= (0.3016)(17) = 5.127$ W

$\dot{Q}$ Steel $= 5.127$ W

$\dot{Q} = \sqrt{hPkA}\ (T_b - T_\infty) \Rightarrow \dot{Q} = \sqrt{(9.334)(0.44)(205)(4\times10^{-4})}\ (37-20)$

$\dot{Q} = 0.5803(17) = 9.8651$ W

$\dot{Q}$ Long fin (Steel) $= 9.8651$ W

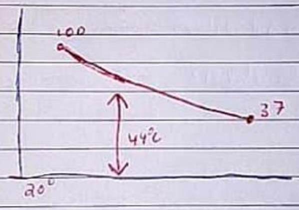
L Theory = 66mm

L Experiment = 75mm

% Error $= \frac{66}{75} \times 100 = 88\%$

$100 - 88 = 12\%$ Error

$T_{LMTD} = 44°C$



Average temperature = 20 + 44 = 64°C

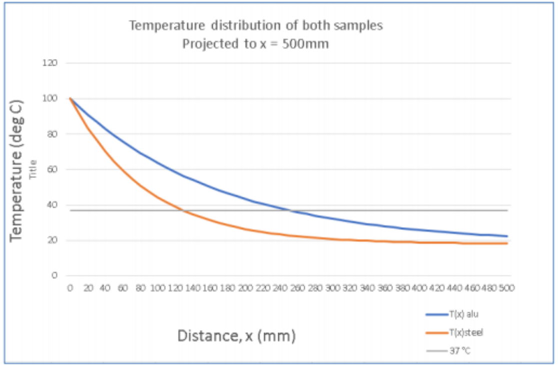


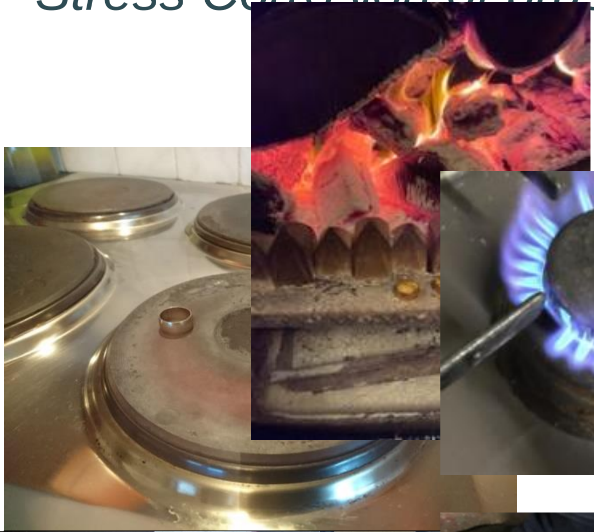
Figure 8 Temperature distribution for both samples.

Task (2) Engineering Material Analysis

They prepared

Stressing the brass rings with pliers

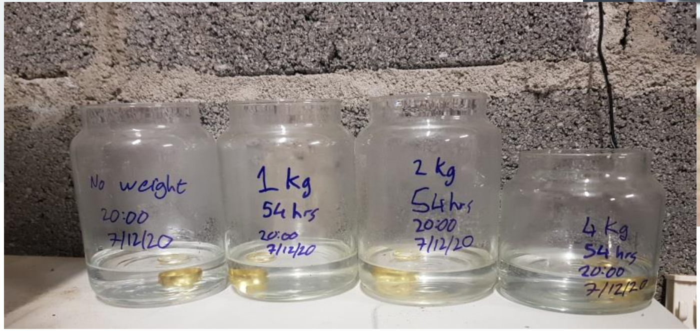
Stress Corrosion of brass rings



Task (2) Engineering Material Analysis

Stress Corrosion of brass rings

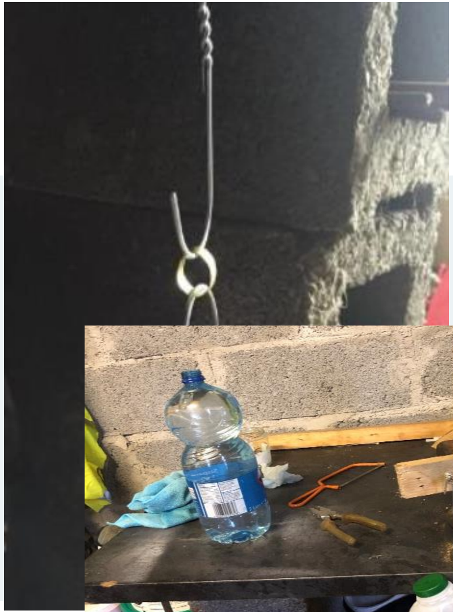
They exposed the rings to the chemical (ammonia)



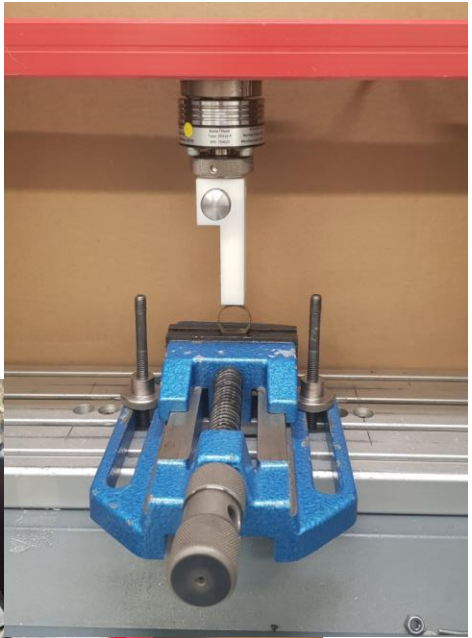
Task (2) Engineering Material Analysis

Stress Corrosion of brass rings

They tested



Hanging weight from l

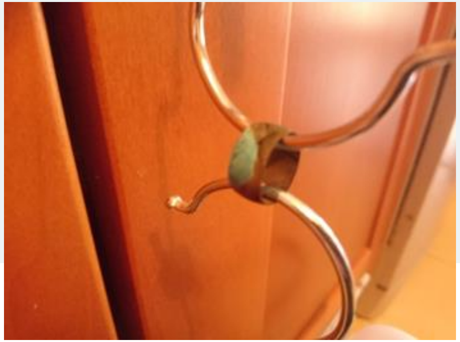


Task (2) Engineering Material Analysis

Stress Corrosion of brass rings

They compared

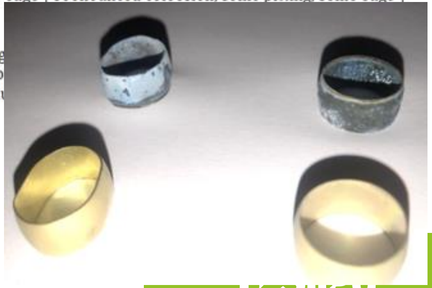
Heat annealed and stressed brass rings after 10 Days in ammonia



Unexposed samples	
Work Hardened	Annealed
Light deformation applied, small but visible gauge marks from pliers jaw.	Darkened finish, light surface corrosion from heat treatment

Table 1 Condition of unexposed samples before tensile testing.

Exposed Samples	
Work Hardened	Annealed
(a) (b) (c)	
Severe corrosion, extensive pitting, some edge erosion. (a) Fracture across band (b) Subsequent separation during handling (c) Differing condition of crack faces, the b face is the new crack that occurred du	Pronounced corrosion, some pitting, some edge



Student Feedback

Students got to experience difference in thermal conduction between two materials.

In most cases the students saw that the theoretical calculations were able to predict the lengths and the amount of heat, with a noticeable difference between aluminium and steel materials.

Some surprise at simplicity of test, and speed of deterioration in jam jars when ammonia present, especially degree of deterioration in stressed samples.

…..At this point the hanger gave in and broke………

…….what can be determined from these results is that if a material is going to be used in a corrosive environment that it is important that the correct material is selected as from this experiment it is seen that it takes very little of a corrosive substance like ammonia to dramatically corrode a material such as brass and therefore running the risk of an accident to stress corrosion cracking………

Areas Needing Attention

Need more guidance on thermal experiment, perhaps explain more in class.

Significant amount of scatter in the results was observed, some rings couldn’t survive handling never mind testing, some rings wouldn’t fail.

A large degree of variation was observed in how the students prepared the rings, exposed to chemical, and finally performed the testing.

Future Recommendations

Refine guidelines on conductance of both tests

Provide better intro and indicative answers for thermal solutions

Conduct Stress Corrosion tests earlier in semester and test all surviving rings in lab.

Overall Evaluation

Optimize relevance, value, and authenticity

Led to an “enduring understanding”….

…..demonstrate that relevance through authentic, meaningful activities………

“engineering does not assign learning to stand-alone subject areas” and that engineers use subject knowledge, understanding and other skills along with tools to solve problems (Katehi et al., 2009).

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Thank You

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