KELSEY LAWSON
41602126

CBEMS 175 SPRING QUARTER, 2011
DESIGN FAILURE INVESTIGATION Prof. J. C. Earthman

HOMEWORK ASSIGNMENT #1
(Due before class on Monday, January 11)

1. Give some reasons why so many failures have occurred and will continue to occur in engineering structures even after many years of experience. What can the investigation of a failure provide in terms of useful information?

   So many failures have occurred and will continue to occur in engineering structures even after many years of experience because over time and especially if unmaintained, the structure will eventually fail. This phenomenon can be related to Murphy's law that states: "Anything that can go wrong will go wrong". But scientifically speaking, this idea is better known as the Second Law of Thermodynamics. This law states: "An isolated system, free of external influence, will, if it is in a state of relative order, always pass to states of relative disorder until it eventually reaches the state of maximum disorder". Hence, due to the concept of time moving forward in our universe, this law is always applied and will eventually have systems break their original state over a long period of time by becoming more disordered, or in this case will exhibit failure.

   Investigating failures provides the ability to learn from the mistakes and begin with greater intelligence to prevent the failure from happening again. Through investigating we learn how the structure was made, what material was used, and what condition the final product was under to now reinvent future structures and material systems and explain why they needed to improve. Possible scenarios that can occur if not adjusted for new tactics are failures leading to accidents or deaths.

2. List three types of microscopes that can be useful for failure analysis with the advantages and disadvantages of each.

   The three types of microscopes that can be useful for failure analysis are as follows: (1) optical (including both micro and macro) (2) SEM (3) TEM

   (1) Optical Microscopes (both macroscopic and microscopic)
   - Pros: (micro) good for low magnification of less that 100x, (macro) no specific camera equipment needed - can even use your phone, and (macro) because it uses a stand and light to see the features the height can easily be adjusted to get various results of the sample
   - Cons: both macro and microscopic optical microscopes observe the surface of the fractured material which limits the any information about failure process, the rate of failure, and where and how it initiated, micro has limited resolution of ~1 micrometer, micro poor depth of field does not allow focus on rough samples, need to polish samples (not all but for those samples that can be) to highlight details such as grain boundaries

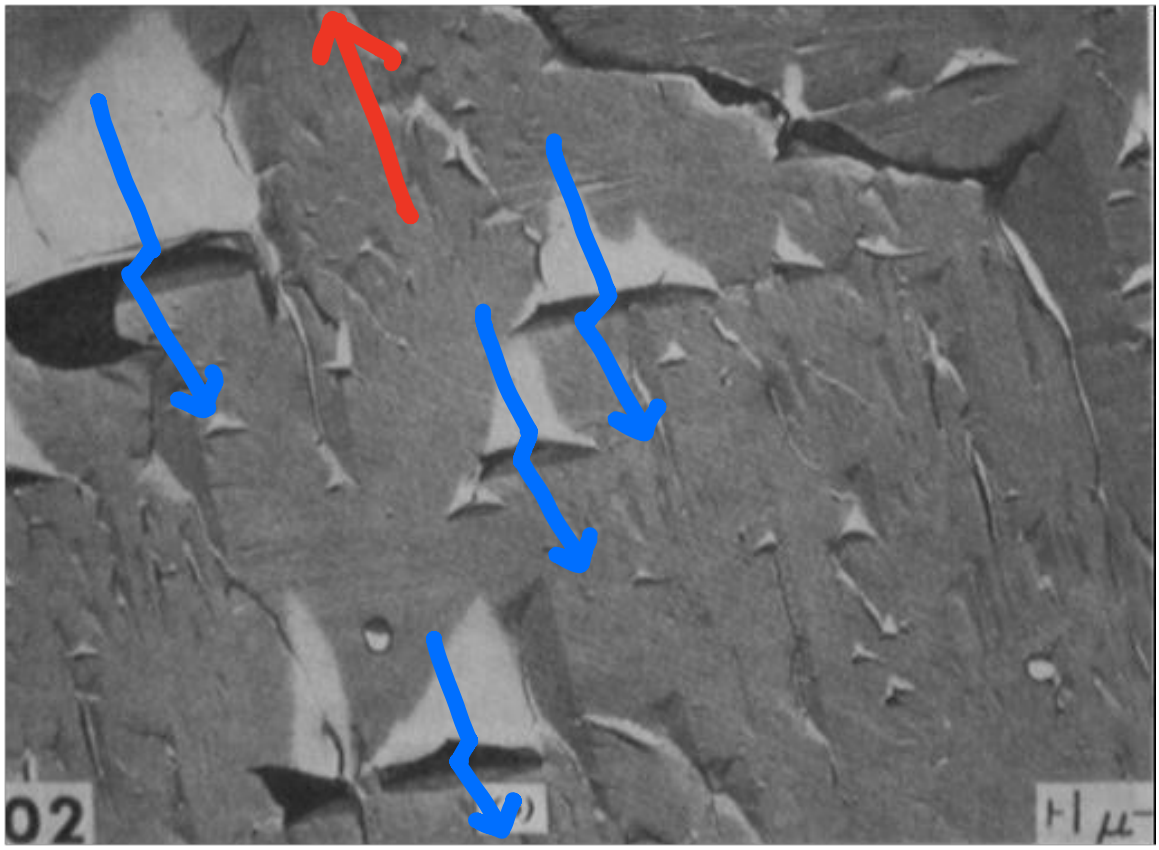
(2) Scanning Electron Microscopy (SEM)

- Pros: good resolution, high depth of field 100x better than optical (can get a lot detail in focus including rough surfaces), can be equipped with energy dispersive spectroscopy (EDS) that uses x-rays to determine which elements are present on the samples surface
- Cons: samples need to be conductive or have a sputtered coating that is conductive, only provides surface level analysis (albeit at a high resolution), uses a fine beam of electrons (<10 nanometers) which requires a vacuum chamber that can not be used on certain samples

(3) Transmission Electron Microscope (TEM)

- Pros: can be equipped with energy dispersive spectroscopy (EDS) that uses x-rays to determine which elements are present on the samples surface, resolution around 0.5-10 nanometers, based on diffraction contrast which means you can get an image of the diffraction pattern inside the sample or get an image of what's in the sample at the image plane
- Cons: specimens have to be thin films, if you can't cut sample into thin films then you have to create a replica to examine the fractured surface,

3. A fracture surface is shown below for a component made of a high strength alloy. What type of failure occurred? Indicate the direction towards the origin of this failure with an arrow?



The failure that occurred on the component made of high strength alloy is a brittle fracture produced by cleavage in crystalline materials. More specifically, this fracture has tongue characteristics.