

Question Numbers Answered	1st Examiner	2nd Examiner (optional)	3rd Examiner (optional)
1a	12/12		
1b	7/8		
2a	9/12		
2b	7/8		
TOTAL	35/40		
RESULT	87.5%		

$$1a) \quad 3.0 = \frac{(1.12 + \alpha(2.91\alpha - 0.64))}{1 - 0.93\alpha}$$

$$3.0 \times (1 - 0.93\alpha) = (1.12 + \alpha(2.91\alpha - 0.64))$$

$$3.0 - 2.79\alpha = 1.12 + \alpha(2.91\alpha - 0.64)$$

$$= 1.12 + 2.91\alpha^2 - 0.64\alpha$$

$$0 = -3.0 + 2.79\alpha + 1.12 + 2.91\alpha^2 - 0.64\alpha$$

$$0 = -1.88 + 2.15\alpha + 2.91\alpha^2$$

$$\frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$$

$$\frac{-2.15 \pm \sqrt{2.15^2 - (4 \times 2.91 \times (-1.88))}}{2 \times 2.91}$$

$$= \underline{0.515\alpha} \text{ positive value}$$

$$-1.254\alpha \text{ negative}$$

$$\alpha = \frac{a}{w}$$

$$\alpha \times w = a$$

$$0.515 \times (25 \times 10^{-3})$$

$$\underline{a = 12.875 \text{ mm}}$$

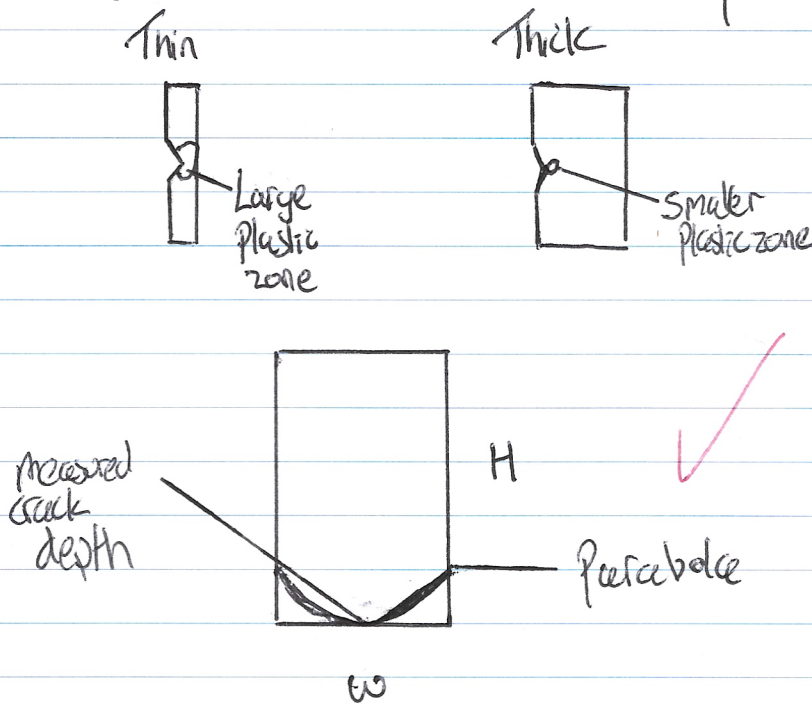
$$K_{Ic} = \sigma \sqrt{\pi a}$$

$$K_{Ic} = (150 \times 10^6) \times 3.0 \times \sqrt{\pi \times (12.875 \times 10^{-3})}$$

$$K_{Ic} = \underline{90.502 \times 10^6} \text{ newtons m}^{\frac{3}{2}}$$

- b)
- Potential drop is the most common method of crack detection, however it is only best used in lab conditions to compare prepared samples. When environmental factors are introduced there is the potential for arcing to interfere with the readings due to difficulties in calibration.
 - Ultra sonic crack detection is becoming more common throughout industry, it is extremely useful for flaw detection, however determining crack depth is extremely difficult due to the sensitivity of the required equipment.
 - Visual inspection has the advantage of being the cheapest and easiest option through the use of dyeing agents. Determining actual crack depth is extremely difficult due to the parabolic effects of fatigue cracking, this compromises accuracy.
 - Eddie current - Using Eddie currents crack detection and measurement readings can be gathered with increased accuracy when compared with PD and Ultra Sonic, however depending on the material type signal attenuation can occur within some materials preventing measurement.

- b) Cracking would normally ~~low~~ when the material goes from a state of plane strain with a small plastic zone size due to a large volume of surrounding material, to a state of plane stress. When in plane stress the velocity of the crack front decreases due to the increase in the size of the plastic zone. Increased deformation occurs within the material causing the crack to become parabolic in nature



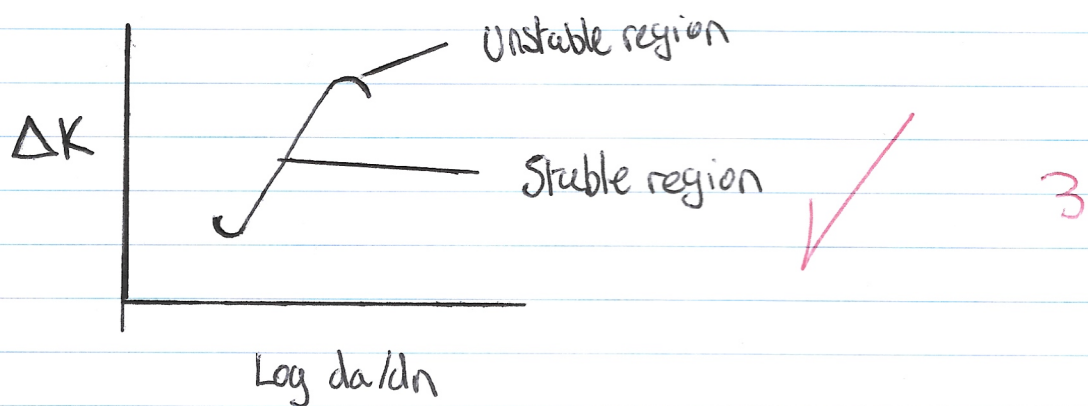
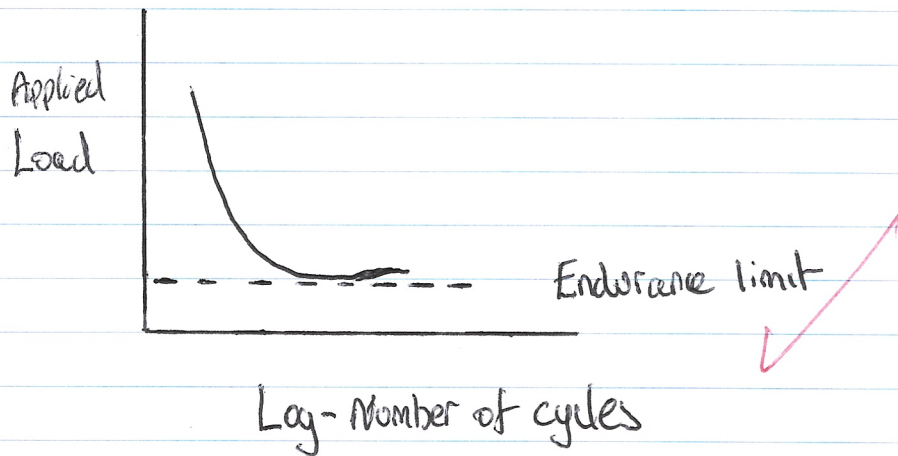
The calculation assumes a uniform crack length however if this is parabolic in nature the area changes so

$\frac{2}{3}$ width $\times$ Height must be applied assuming a uniform parabola

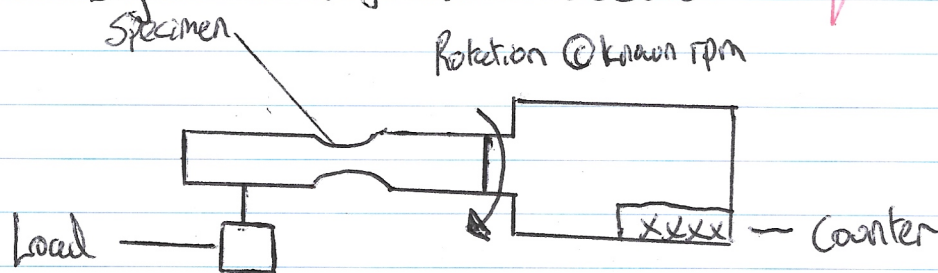
$\frac{7}{8}$

2a

S/N = Stress - Number of cycles



The S/N curve is produced using the cantilever test for fatigue where a polished and blended specimen is placed in a rotating fixture at a given rpm and is subjected to cyclic / ~~sinusoidal~~ testing. The number of rotations is counted and then Logged till failure occurs:



The reason the surface of the material is blended and polished is to reduce the build up of stress concentration points along the material edge.

A typical da/dN Delta K curve tracks the velocity of crack movement within the material, during the initial formation of the crack and final failure of the material. This velocity is unstable in nature ~~the~~. However when established a stable region is formed with predictable growth rates. This is extremely useful in aviation as it allows life cycles for materials to be estimated in advance. In reality ~~that~~ this function has its limitations as there is often a scattering effect.

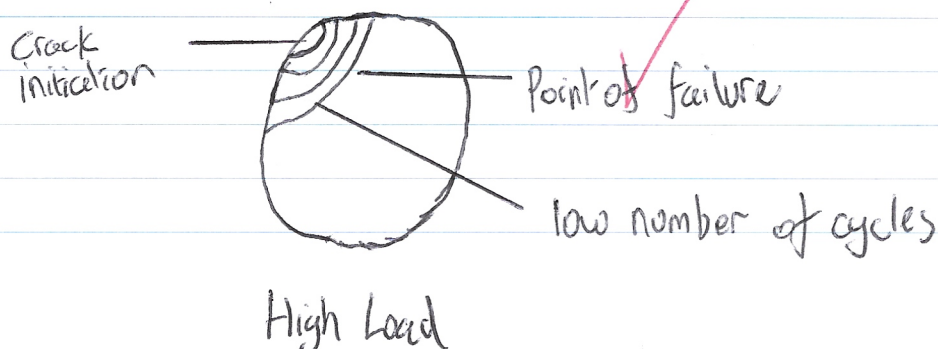
The S/N curve when establishing an endurance limit can also be misleading. It assumes a lab environment with the exclusion of environmental factors. Corrosion, creep, wear will all affect the material in a practicable environment.

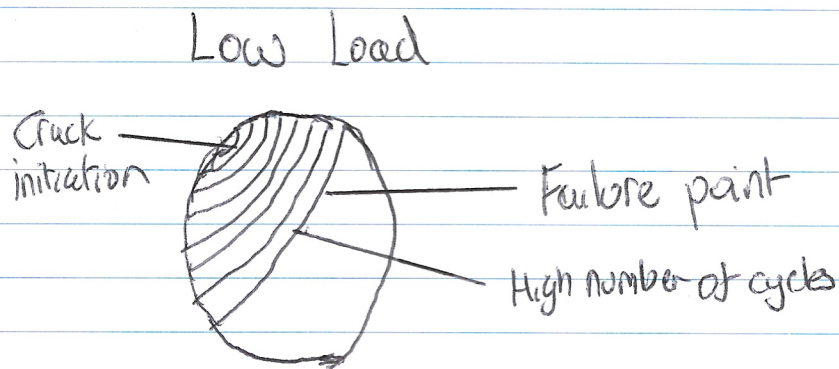
9/12

2b

- Operating procedures
- Bending of corners and edges
- Polishing / Improved surface finish
- Compression through peening / ~~initiation~~ autofrettage

Through operational changes such as reduced load and cycle rate it is possible to reduce the rates of fatigue within a material increasing its life. High loading increases the velocity and formation of cracking leading to premature failure ~~at~~ which is often brittle in nature.



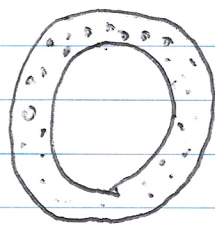


Low loading increases the number of cycles a material is capable of withstanding.

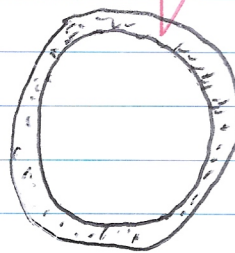
Through the blending of corners and edges the effects of stress concentration are reduced. Sharp edges are most often the sites of crack ~~max~~ formation either due to manufacturing error or load being applied through a smaller internal angle. The issue with blending is the increased cost of production and therefore is not always practicable.

Polishing and improved surface finish allow for the removal of crack initiation sites before the material is stressed. Reduced imperfections take longer to propagate through a material (metal).
Additional cost again is introduced.

Surface compression such as peening or autofrettage in gun barrels introduces positive stresses within a material prior to use. It also has the effect of increasing surface hardness which combats fracture formation. Density of the material will be increased.



Before compression



After compression