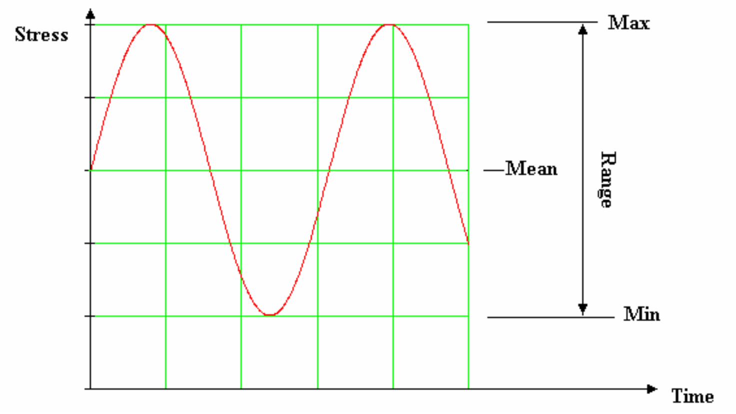
8. (a) Define the following 4 terms in relation to fatigue.

Stress amplitude Mean stress Fatigue limit Endurance limit.

(b) A cast steel component in a mass produced item is found to have failed due fatigue in service. It is not feasible to change neither the main dimensions nor the loading. Suggest what changes might be made to extend the life and explain your reasoning.



When the stress in a component varies sinusoidal with time, the stress amplitude is half the range shown on the diagram and the mean is the middle of the range. The mean is not necessarily zero. The fatigue strength is significantly reduced when the mean is tensile.

σ_m = mean stress = $(\sigma_{max} + \sigma_{min})/2$

σ_a = stress amplitude$(\sigma_{max} - \sigma_{min})/2$

When the variation is not sinusoidal, the definition is the same.

The fatigue strength is the stress level that produces failure after a specified number of cycles. This is also called the fatigue limit. If the tensile stress never exceeds a minimum level in most materials, fatigue failure will not occur. This stress level is called the **endurance limit.**

(b) The fatigue life of the component may be increased by paying attention to the following.

- Stress concentrations factor
- Corrosion
- Residual surface stress
- Surface finish
- Temperature
- Bulk mass (size) of the component
- The way the stress fluctuates

Nothing can be done about the last two but stress concentrations due to keyways, holes, grooves, undercuts, corners any surface mark may be improved with attention to design.

Corrosion takes many forms and weakens the metal. Surface deterioration may set up stress raising factors. Corrosion of some metals spreads along the grain boundary and so weakens the material. It has been known for a component to fail in fatigue because a chemical marker had been used to write part numbers on the surface and the chemicals etched into the surface and weakened the grain boundaries in that region. Paying attention to the environment may help.

Residual surface stresses can be set up by bending the material thus leaving a permanent stress in it. If the surface has a residual compressive stress, this is beneficial and may be produced by shot blasting or peening.

If a surface is very smooth, there are no points for a crack to start and no stress raisers. Polishing a component improves its fatigue life. For example, the connecting rods on racing car engines are designed to have the minimum mass possible and so are designed with a very small stress safety margin. This would leave them prone to fatigue failure and polishing them makes fatigue failure less likely. On the other hand, rough surface finishes say from turning on a lathe, reduce the fatigue life. Components have been known to fail in fatigue simply because a part number was engraved on the polished surface.

Hot temperatures cause surface oxidation and degradation and so reduces the fatigue life. Thermal expansion and contraction is itself a cause of fatigue stress For example, the leading edges of aeroplanes get hot in flight and cool at other time causing expansion and contraction. Aeroplane body panels are often shaped by shot blasting so inducing a compressive stress on the surface to counteract fatigue.