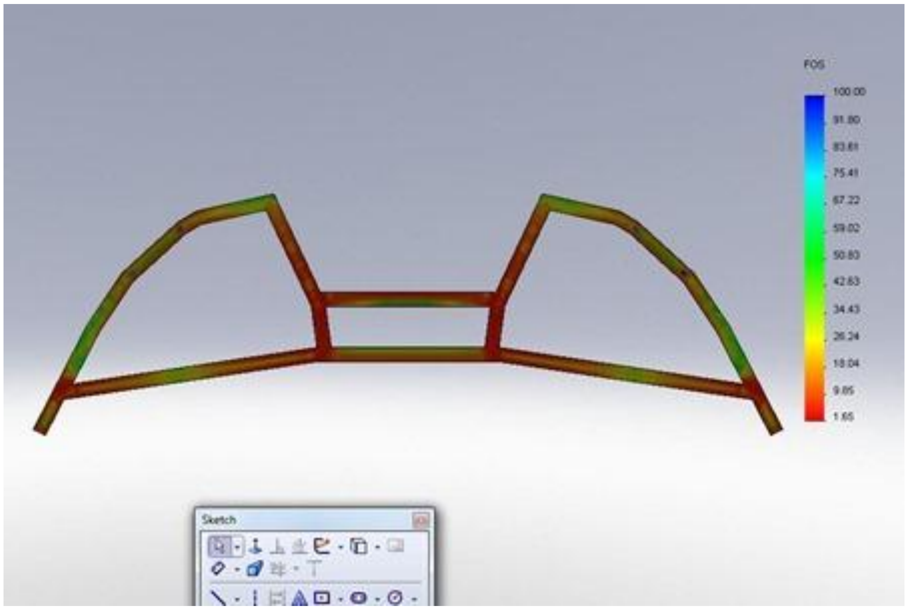
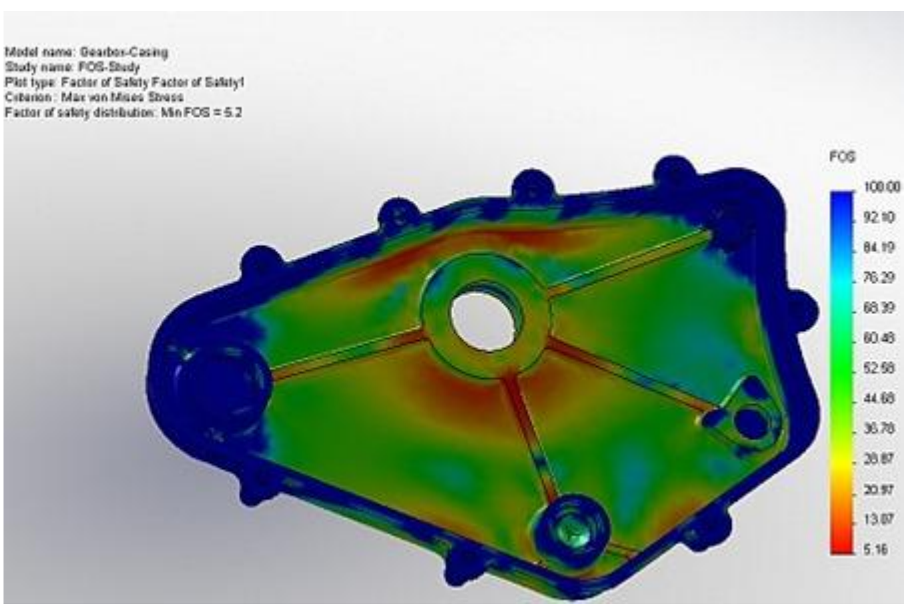
Factor of Safety, FOS



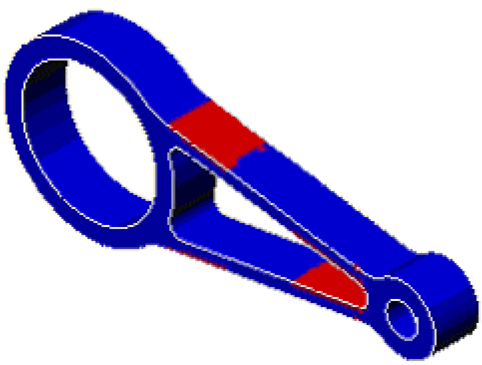
It is common practice to size the machine elements, so that the maximum design stress is below the UTS (Ultimate Tensile Stress) or yield stress by an appropriate factor – the Factor of Safety, based on UTS(Ultimate Tensile Stress) or Yield Strength. The factor of safety
also known as Safety Factor, is used to provide a design margin over the theoretical design capacity to allow for uncertainty in the design process. Factor of safety is recommended by the conditions over which the designer has no control, that is to account for the uncertainties involved in the design process.



The uncertainties include (but not limited to),

- Uncertainty regarding exact properties of material. For example, the yield strength can only be specified in between a range.
- Uncertainty regarding the size. The designer has to use the test data to design parts which are much smaller or larger. It is well known that a small part has more strength than a large one of same material.
- Uncertainty due to machining processes.
- Uncertainty due to the effect of assembly operations like riveting, welding etc.
- Uncertainty due to effect of time on strength. Operating environments may cause a gradual deterioration of strength, leading to premature and unpredictable failure of the part.
- Uncertainty in the nature and type of load applied.
- Assumptions and approximations made in the nature of surface conditions of the machine element.

Selection of factor of safety



The selection of the appropriate factor of safety to be used in design of components is essentially a compromise between the associated additional cost and weight and the benefit of increased safety or/and reliability. Generally an increased factor of safety results from a heavier component or a component made from a more exotic material or/and improved component design. An appropriate factor of safety is chosen based on several considerations. Prime considerations are the accuracy of load and wear estimates, the consequences of failure, and the cost of over engineering the component to achieve that factor of safety. For example, components whose failure could result in substantial financial loss, serious injury or death usually use a safety factor of four or higher (often ten). Non-critical components generally have a safety factor of two. Extreme care must be used in dealing with vibration loads, more so if the vibrations approach resonant frequencies. The vibrations resulting from seismic disturbances are often important and need to be considered in detail. Where higher factors might appear desirable, a more thorough analysis of the problem should be undertaken before deciding on their use.

- 1.25 – 1.5

– Material properties known in detail. Operating conditions known in detail. Loads and resultant stresses and strains known with with high degree of certainty. Material test certificates, proof loading, regular inspection and maintenance. Low weight is important to design.

- 1.5 – 2
  – Known materials with certification under reasonably constant
  environmental conditions, subjected to loads and stresses that can be determined using qualified design procedures. Proof tests, regular inspection and maintenance required.

- 2 – 2.5
  – Materials obtained for reputable suppliers to relevant standards
  operated in normal environments and subjected to loads and stresses that can be determined using checked calculations.

- 2.5 – 3
  – For less tried materials or for brittle materials under average
  conditions of environment, load and stress.

- 3 – 4
  – For untried materials used under average conditions of environment, load and stress. Should also be used with better-known materials that are to be used in uncertain environments or subject to uncertain stresses.

Usually the factor of safety is kept larger, except in aerospace and automobile industries. Here safety factors are kept low (about 1.15 – 1.25) because the costs associated with structural weight are so high. This low safety factor is why aerospace parts and materials are subject to more stringent testing and quality control. Now computers are being used to provide more accurate simulation of stresses that occur in components, particularly in the case of high value products where safety and saving weight is essential.

Source:

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