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14:00 pm M6X00420 Advanced Stress and FEA

1 (a) FEA is the simulation of a physical object using a numerical mathematical technique referred to as finite element method. Doing this simulation can reduce the number of physical prototypes used as the simulation will give multiple different results that will test the engineer/designer if the physical prototype is suitable or not. There are multiple different types of analysis that will give different sorts of results. Linear static analysis can be used, which using Hooke's Law will understand the relation between loads on the object, and the displacement of the object, so that the designer/engineer can understand the stiffness of the design under analysis. Dynamic analysis is used to evaluate the impact of transient loads or to alter design's from potential noise and vibration problems, which can be very common in a manufacturing environment, which would be more difficult to test physically, as vibration analysis testing is expensive. Thermal analysis, looks into the heat transfer of the design, with understanding the temperature distribution and thermal loads of the design, the engineer/designer will understand the thermal stress the design is under. This would be more difficult to analyse with a physical prototype as it is difficult to precisely

measure the thermal distribution in an object, without the chance of human error. Fatigue analysis can be tested which can accurately define stress concentration effects in the geometry features of the design. Which will give the designer understanding of what potential areas of failure in the part could be an area of concern that will need to be addressed. Finally there is optimisation analysis, in particular topology optimisation which will optimise the material layout of a given design space, with the aim to maximise the performance of the design. This would allow the designer to create a component that would be less material and more efficient, which could save costs in material and processing, and would be difficult to achieve such results through a physical prototype. Ultimately FEA will give the designer/engineer understanding of potential causes of concern, with less needs for a physical prototype.

- (b) Physical prototypes are still important as, FEA is not 100% accurate, and just because they give certain results doesn't mean the component won't eventually fail. In using the FEA human error could be made, as if a wrong figure, or load was applied for example it could show negative results that may not be true. Physical prototypes could be important for a

customer, so that they can actually understand what the component would look like. The prototype depending on the material can still be cheap, and altered should any changes be required without concern of overall costs.

(C) Correlation is needed between testing and FEA, as it will give understanding to the designer/engineer what the results show, and if the design is suitable for manufacture. It is important to understand the useful results that can be taken from FEA and compared with the testing of the prototype. As using the FEA results a prototype could be created, where the testing on it, can support/confirm with the FEA results. The same can also be said for doing an FEA on a prototype design could be beneficial as it will analyse the results.

2. (a) Pre-processing describes preparing the FE model before analysis can be carried out, which can follow the acronym, SIMPL

Split - The first step is to split the geometry down into finite elements, so that mathematical assumptions can be made from one element to the next. The element type, order and density need to be considered.

Interpret - To obtain reasonable results in a reasonable time the geometry needs to be approximated (small details that add complexity to the analysis would need to be interpreted into whether they should be simplified or ignored).

Material - once design is simplified and meshed, the material information needs to be added.

Physical property - If 1D or 2D elements are used, then the physical property information needs to be added to the model. If 3D elements are being used, then the information is defined by the geometry of the elements.

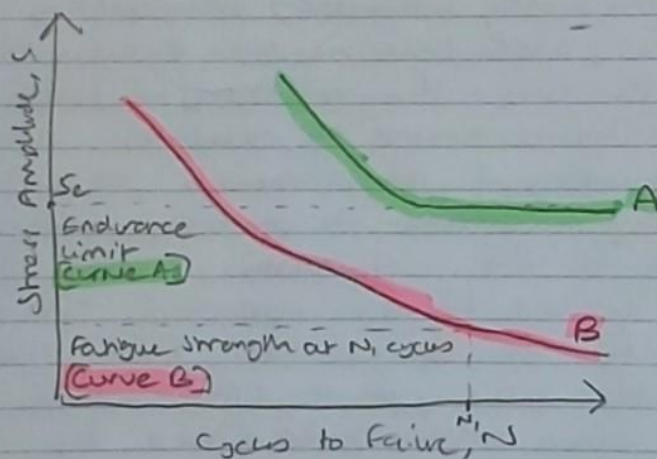
Loading - once information has been added to FE model the solver will be able to calculate the stiffness matrix for the structure. From this simultaneous equations can be obtained. The loading and boundary conditions are needed to solve these.

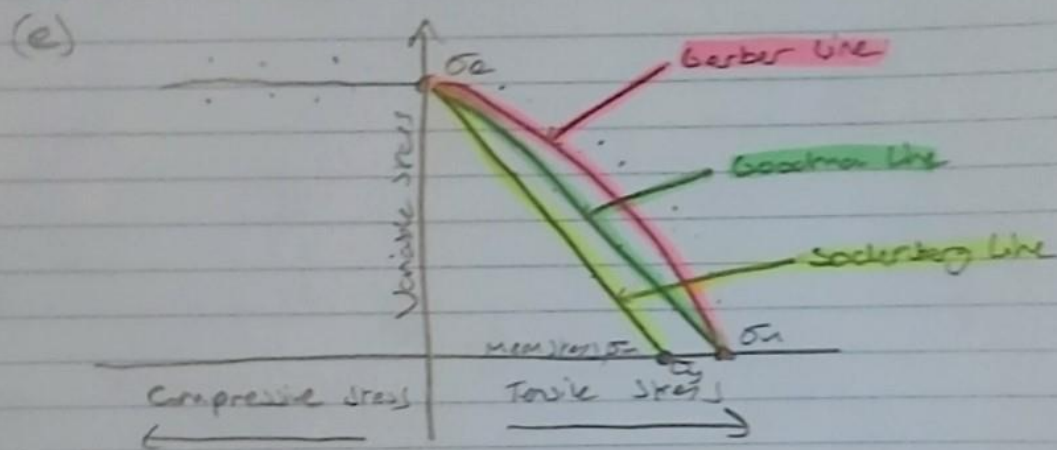
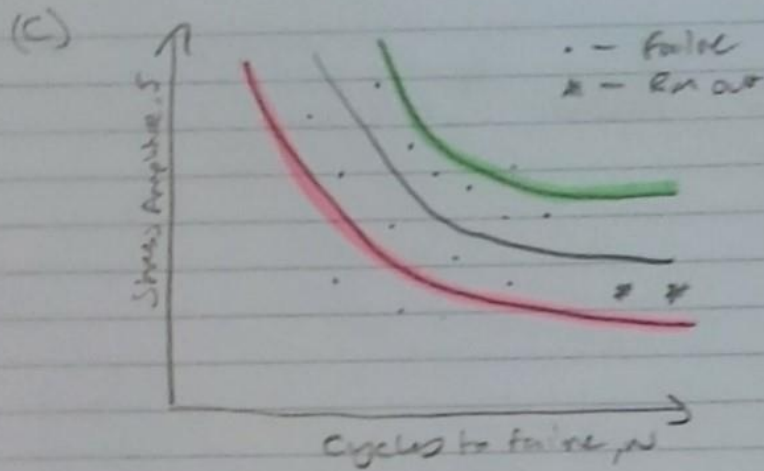
(b) Processing describes the computer actually carrying out calculations, using matrix algebra. In order to solve the equations generated from the stiffness matrix and the boundary conditions. While the pre/post processing phases of the finite element method are interactive and time consuming for the analyst, the processing stage is often a batch process, and is demanding of computer resources. The governing equations are assembled into matrix form and are solved numerically. The assembly process depends not only on the type of analysis, but also on the model's element type and properties, material properties and boundary conditions.

(c) Post processing describes interpreting the results, also known as evaluating the results. Once the model has been solved the analyst needs to evaluate the results. Understanding if any previous step in the process influenced the results, understanding if any of the information in the previous steps needed to be updated. That a computer to carry out FEA can only give approximate results. Understanding that what ever data is inputted by the user will directly influence the results, meaning if some data is wrong then the results will be wrong.

4. (a) SN-curves are an apparatus to apply repeated loads to railroad axles and chart the relationship between load level and number of repeated cycles to failure. Using SN-curves, cyclic stress can be better understood and fatigue can be considered. SN-curves can be developed by using a metal specimen testing machine. A small metal specimen is placed into the machine and subjected to a cyclic stress time history until a crack or failure occurs in the metal specimen. Several specimens must be tested at different stress levels to develop a SN curve.

(b)





The Gerber Line indicates the region just beneath the failure points during experiment.

The Goodman Line is a safer consideration than Gerber because it is completely inside the Gerber line and excludes some of area which is nearby failure region.

The Soderberg Line is even more conservative and much safer method.