Seven Steps to Setup a Fatigue Analysis

SolidWorks Simulation Professional allows for the setup/evaluation of a virtual fatigue analysis within the SolidWorks product suite. This will allow the user to answer the question as to whether a product will withstand usage requirements over a period of time and not just if the product will hold up to a single specified load environment. Below are the steps to complete a successful analysis:

1. Determine Load Type During Study Creation

There are two types of loading available when defining a fatigue study: constant amplitude and variable amplitude events. When defining a fatigue study, there are two options at the bottom of the new study dialogue window to choose from. One is for defining a constant amplitude fatigue study and the other is for defining a variable amplitude fatigue study.

All cycles of a constant amplitude event have the same alternating and mean stresses. A constant amplitude event is fully defined by an alternating stress, mean stress and the number of cycles. A fatigue event can refer to one of more static studies (linear and nonlinear), or to a particular solution step from nonlinear or modal time history dynamic studies. The software calculates the worst alternating stress levels for each event. A variable amplitude event is a load history record that defines the fluctuation history of a load.
2. Adding Events

Constant amplitude event:

Input the number of cycles for the event (i.e. 1,000,000 cycles). Specify the loading type (Fully Reversed, Zero Based, Loading Ratio and Find Cycle Peaks). Select the reference study(ies) to tie to the event.

A fully reversed load would be an application where a load is fully reversed for a set number of cycles (i.e. a 1000 lb force load in the X direction is oscillating between the positive and negative X directions. Essentially, the software changes the value of the load from positive to negative for a single cycle and the analysis is run for a set number of cycles). The loading ratio for a fully reversed load is -1. Loading ratio is defined as the minimum load divided by the maximum load. This event is based on one reference study.

A zero based load would be one where a load is varied between zero and the value of the load (i.e. from 0 to 1000 lb). Another way of stating this would be to call it an on/off load. The loading ratio for this scenario is 0. This event is based on one reference study.
The loading ratio option allows one to specify a user defined loading ratio (i.e. a scenario where the event is not fully reversed or zero based). If the load cycle oscillates between -5 lb to +100 lbs, then the loading ratio would be -0.05 (-5lb/+100 lb). This event is based on one reference study.

The find cycle peaks event type is based on multiple reference studies. The program uses the stress results of the specified studies to find cycle peaks that give the highest alternating stress for each mesh node. An example of this would be if you evaluating a scenario where a dead load is present (i.e. non-oscillating).

Variable Amplitude Event:

Apply the variable load history curve. Specify the reference study to tie to the event. Specify the number of repeats for the load history curve and the start times if multiple events need to occur in a specified sequence.
3. Defining the Fatigue Data

The software uses a S-N curve to evaluate the fatigue results. A S-N curve defines the alternating stress values versus the number of cycles to failure at a given stress ratio. When defining the reference studies, one can specify a material that has fatigue data already inputted for the material. In the SolidWorks material database, the materials that have "SN" appended to the name already have a S-N curve defined. For these materials, the S-N curve is based on a fully reversed load (i.e. the stress ratio is -1). If the reference studies do not have S-N data tied to their materials, then one can manually input this data. It is possible to apply up to ten S-N curves calculated empirically for different stress ratios. This is important when mean stress needs to be calculated correctly. Lastly, if one is using an ASME Austenitic Steel or an ASME Carbon Steel, then the software can derive the S-N curve from known ASME S-N data.

The results of a fatigue analysis are highly dependent on the quality of the input S-N curve(s).
4. Result Options

Fatigue calculations can be run for the whole model (default option) or surface only.

5. Fatigue Study Properties

Constant amplitude study options include how to define constant amplitude event interaction, how to compute alternating stress and how to take into account mean stress (mean stress correction type) when there are not enough defined SN curves to accurately account for mean stress.

Variable amplitude study options include defining the number of bins for rainflow counting as well as the alternating stress and mean stress options.
6. Run the Analysis

A fatigue analysis runs very quickly. The reference studies are not rerun.

7. Postprocess the Results

Three plots are available to help evaluate the results of the analysis (Life, Damage and Factor of Safety).

The life plot depicts the number of cycles that causes failure at a model location (i.e. mesh node point). For example, a life plot may show a specific node point with a value of 150,000. This means that point can withstand 150,000 cycles before failure. The life plot is only available when a single event is defined for the analysis.

The damage plot depicts the percentage of damage at a model location. A value of 1 indicates that the defined fatigue event consumes 100 percent of the model life at that location.

The factor of safety plot is very similar to the factor of safety plot for static analysis. A factor of safety of 2 at a model location predicts fatigue failure at that location when the applied loads are multiplied by 2.