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CAE Correlation Optimization of Automobile Body Structure Fatigue Failure

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Abstract: **In today's automotive industry CAE is very useful for predicting fatigue failures during design phase. But due to many constrains of CAE model and manufacturing process correlation in some cases may vary. From business point of view it is always desirable to have 100% correlation so that in later stage of the project while doing physical validation design change is minimum. As we know CAE cannot replace experiments hence we should always try to achieve better correlation. In this paper we will discuss about the CAE pre-process, solution, material properties, manufacturing formability, part quality, assembly process and environmental factors for better correlation as these factors are very critical from correlation point of view. By managing these critical factors within desired tolerance we can maximize correlation.**

Keywords: **Catia-V5, Abacus, FATFEM.**

I. INTRODUCTION

From durability engineering point of view most important terminology we encounter in terms of automobile body structure are panel fatigue and spot fatigue. A good durable structure can be referred as resistance of the structure to resist cracking. Although in actual practice it is impossible to manufacture body structure which will be having infinite life therefore manufacturing industries designs car under limited life consideration.

The purpose of durable design is to minimize in service maintenance cost and maximize operational readiness.

In this paper our main focus will be on sheet metal panel fatigue and spot weld fatigue.

Basically in both the cases important parameters are proper selection of material, thickness, stress level and forces on spot and its mode (tensile, compression or shear) etc.

For better correlation special precaution has to be taken care in CAE, Part manufacturing and its joining process. All these three mentioned factors with contribute the actual result hence deviation of any factor will result in poor correlation. Another factor we want to mention here is environment. Environmental factors like humidity will make structure prone to corrosion. Corrosion near high stress area will result in early failure.

II. SHEET METAL PANEL FATIGUE

Sheet metal panel fatigue failure happens due to high local stress induced, notch factor, residual stress, preload condition, part quality problem and corrosion.

Failure may happen because anyone above mentioned factor or in combination.

Factors to be considered for metal fatigue:

Fatigue is a highly localized phenomenon and depends on stress and strain experienced in the critical regions of the component or structure. The relationship between uniaxial stress and strain for a given material is unique, consistent and in most cases independent on location.

The critical relationship between stress and strain must be modeled in cyclic material response rather than static. Cyclic stress strain curve takes into account the softening or hardening behavior of the material.

The fatigue life prediction process for a critical region in a component or structure consists of several closely interrelated steps. A combination of material cyclic properties (material properties), Stress concentration load (stress analysis) and the load history (service load) can be used to simulate the local stress strain response in critical areas. Below are the factors to be taken care for better correlation.

A) Material Variability:

In CAE simulation we assume the material as isotropic in composition having defined yield and tensile stress. But in actual practice material cannot be isotropic and also its yield and tensile stress varies. To counter this issue we need to have sufficient available tested material data so that standard statistical procedure can be applied to fit the data in the assumed life relation.

For example we can have 50 sample material tested and collected yield and tensile stress data. So for better correlation we should consider the mean value while doing the simulation.

Normally the relationship between stress and strain for a given material is unique, consistent and in most cases independent on location.

The critical relationship between stress and strain must be modeled in cyclic material response rather than static material response. Cyclic stress strain curve takes into account the softening or hardening of the material.

The fatigue life prediction process for critical regions depends on few closely interrelated steps. A combination of load history (service load), stress concentration factor and material cyclic properties can be used to simulate the local stress – strain response in critical areas.

Some of the important material properties are:

- Elastic modulus.
- Yield strength
- Ultimate tensile strength
- % of reduction in area
- True fracture strength
- True fracture ductility
- Strain hardening exponent
- Strength coefficient

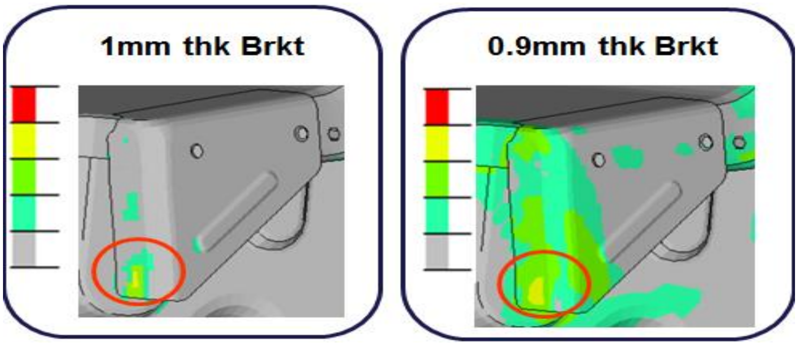
For all the properties mentioned above we need to have proper statistical data to be applied during simulation rather than standard value.

For considerations for the analysis procedure are construction of confidence limits on mean curve and on the equation parameters, construction of tolerance limits on the fatigue response of a material, probability-stress life curve construction, treatment on runouts, characterization of fatigue behavior and fatigue strength a material lot and consolidation of fatigue data generated at different conditions (The different condition may include source or heat, mean stress Or strains, notch concentrations and temperature).

B) Material Thickness:

In addition to Material property variation thickness variation is also important. In CAE we assume constant thickness but in actual part thickness variation will be there.This has to be taken care for CAE simulation.

Below fig represents change in stress level of 50Mpa due to material thickness (change in thickness from 1mm to 0.9mm)



C) Preloading Effect:

Preloading at notch:

Preloaded engineering material have very significant impact on Fatigue behavior of material. In general we assume that tensile preloading might limit the crack growth rate while the compressive loading shows the reverse one. Preload normally arises because of manufacturing part quality And assembly issues. This factor has to be considered as it greatly Impacts correlation.

Preloading at spot Joint:

After actual assembly in manufacturing plant due to assembly variations If there exist any preload condition nearby any spot joint this will greatly impact the fatigue life of spot. Preloading may be tensile or compressive. Hence during simulation as far as possible we should include pre load condition as this preload gets added to the actual load pattern

Preloading in bolted joint:

For effective bolted joint it is always desirable to have more Contact area between the mating panel and bolt head. But in some cases due to assembly issue there may be preload exist. Preload may be tensile or compressive. As a result of which there will be change in contact area. This change in contact area will give different result as compared to Ideal condion. Hence while modeling bolted joint preload condition has to be considered.

D) Manufacturing constraints:

Part manufacturing:

a) Part quality:

Now a day's all the OEMs are looking for low cost Manufacturing. But as side-effect of cost benefit part quality gets affected. For example for some part manufacturing we may have two options like forming and drawing. Since forming is cost effective people want to go for it but faces part quality issue This quality issue will impact during assembly process as preload Issue.Hence manufacturing of any part, quality has to be given high priority rather than cost.

Part quality can be addressed in CAE model by taking forming simulation data as input.

b) Assembly Quality:

Assembly quality two basic parameters (weld spot quality and material handling) we are going to explain in this paper.

Weld spot quality means spot weld quality and its desired location. Weld spot quality can be controlled with proper flow of current using robots. Also proper pitch has to be maintained between two spots to avoid shunting effect.

In CAE it is not possible to model spot quality. During assembly it is impossible to match exact weld spot location as designed because of part and assembly tolerance constrains. The parameter that we can control during assembly is to maintain minimum tolerance by improving part quality and use of robot during joining process.

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Material handling means how the parts/subassembly handeled during logistics. Sometimes parts and subassembly.encounter damage while transporting. In CAE it is not possible to model this issue. What we can do in this case are more stiffer part design and with proper material handling process.

E) Environment Factors:

Aggressive environment has significant influence on fatigue crack growth rates as well as crack initiation.It is apperant that crack growth rates are lowest in argon. Water considerably accelerates the crack growth rates and are enhanced further by addition of chloride,iodide and bromide at open circuit potential.Some of the factors that influence corrosion fatigue crack initiation behavior also effects fatigue growth behavior.The crack growth rates are increased by an order of magnitude at cathodic.From design point of view by making rust free body we can mininmize metal fatigue failure due to corrosion.

F) Mesh Quality:

For high stress regions it is always recommended to do mesh refinement by reducing its size .Normally stress level variation before and after refinement remains with be within 5-20%.

III. CONCLUSION

Although it is not possible to correlate everything in CAE but we should try to maximize correlation as much as possible by CAE optimization and controlling part quality and assembly process.

REFERENCES

[1] SAE Fatigue Design Handbook.