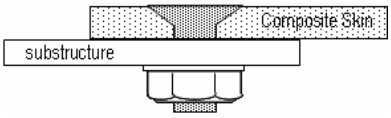
Proposed Research to Determine
Countersink and Fastener Clearance Effects

Background – Countersunk Fasteners

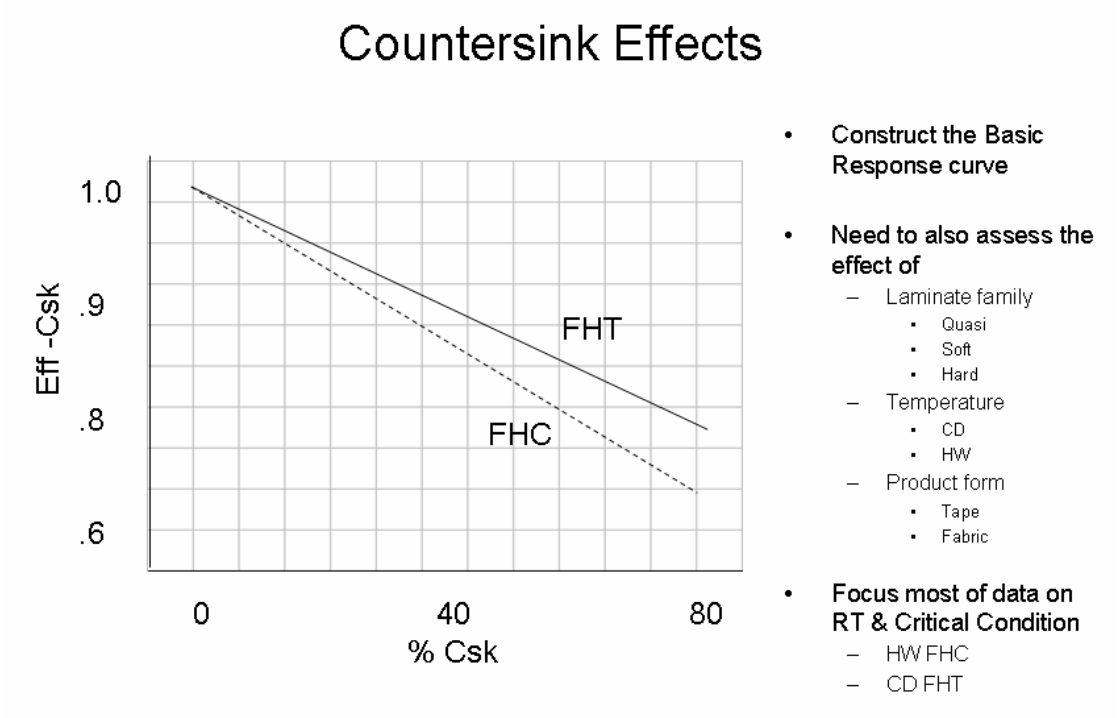


Composites are used extensively for aircraft skin panels that are exposed to the air stream surface (OML). For military and the majority of large commercial aircraft these OML skin panels are attached to the substructure using fasteners. Aerodynamic and other requirements dictate that these fastened joints be flush or in many cases sub flush with the OML. To accomplish this all the OML composite panels are fastened to the substructure using so-called countersunk fasteners. The presence of the countersink in the composite laminate effects several of the critical mechanical properties that can size the panel such as Filled Hole Tension (FHT), Filled Hole Compression (FHC) and Bearing.

Basic material property testing usually only tests protruding head conditions leaving it up to each user/program to determine the materials behavior in a countersunk joint. Prime aerospace contractors have handled the presence of the countersink in the laminate using multiple approaches including; developing all the basic material property allowables using specimens containing countersinks and using countersink knockdown effect curves from prior programs and applying them to the new material systems.

Proposed Project – Determination of Countersink Effects

For each property of interest (FHT, FHC OHC, Bearing) determine the basic relationship between a non-countersunk and countersunk joint. Further determine if any of the following variables; laminate orientation (quasi, hard, soft), material product form (uni-directional tape, fabric), material type (IM fiber BMI, IM fiber toughened epoxy, IM fiber vacuum bag cure, SM fiber vacuum bag cure, etc.), temperature, degree of countersink, effect the basic relationship.



The proposed test matrix to accomplish this is attached and seeks to leverage the ongoing NCAMP materials data generation efforts as well as other material data generation activities ongoing within the DoD and at the material suppliers.

The theory is that for each property a single curve can be constructed that captures the effect of the countersink. Data from this research effort will confirm this theory and/or identify the variables that alter the relationship and permit modification factors to be derived. The end results from this effort can and will be broadly applicable to the entire aerospace industry. It will permit the more rapid generation of new material property data (won't have to always test all the countersink effects) and facilitate new materials insertion.

Background – Fastener Fit/Clearance Effects

Mechanically fastened composite joints continue to be widely used in the aerospace industry and will be for the foreseeable future. These fastened joints contain many variables. One variable that effects the behavior of the joint is the so called "fastener fit". Multiple types/classes of fit are used throughout the industry and there is no common terminology to describe it. While all of the aerospace companies agree on that the definition of a "tight fit" is from 0.000" to +0.003" the definitions of so called looser fits varies. The degree of fit/clearance between the fastener and the hole in the composite laminate effects several of the critical mechanical properties that can size the panel such as Filled Hole Tension (FHT) and Filled Hole Compression.

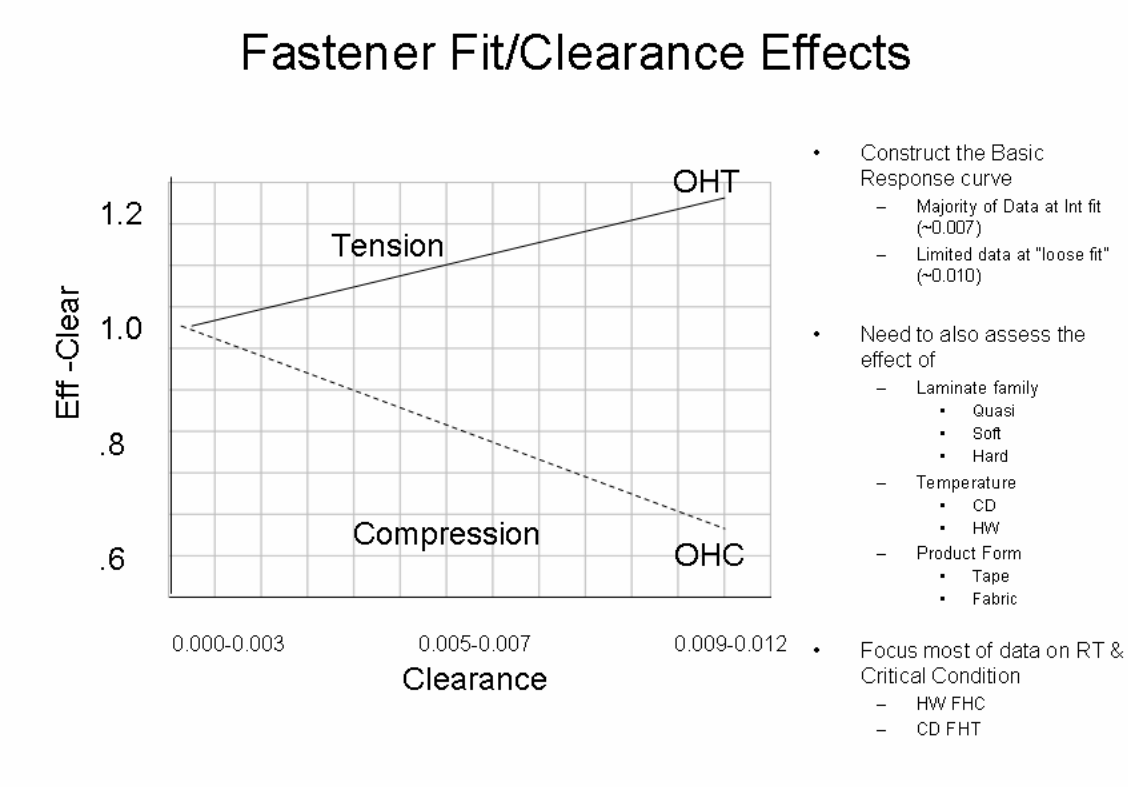
Basic material property testing usually only tests tight fit, protruding head conditions, leaving it up to each user/program to determine the materials behavior in the looser joints. As the clearance approaches +0.015" the FHT and FHC behavior approaches that of the open hole condition. Prime aerospace contractors have handled the various clearances in the laminate joint using multiple approaches including; developing all the basic material property allowables using specimens containing multiple clearances and using open hole values for all conditions other than tight fits. In today's design environment which seeks to maximize the weight savings associated with the use of composites the later approach is less attractive.

Proposed Project – Determination of Fastener Clearance Effects

For each property of interest (FHT & FHC) determine the basic relationship of three fastener clearance conditions. The proposed conditions (subject o agreement by the aerospace primes) are:

- "Tight" Fit – 0.000"-+0.003"
- "Intermediate" Fit – +0.006"-+0.008"
- "Loose" Fit - +0.009-+0.012"

Further the project will determine if any of the following variables; laminate orientation (quasi, hard, soft), material product form (uni-directional tape, fabric), material type (IM fiber BMI, IM fiber toughened epoxy, IM fiber vacuum bag cure, SM fiber vacuum bag cure, etc.), temperature, effect the basic relationship.



The proposed test matrix to accomplish this is attached and seeks to leverage the ongoing NCAMP materials data generation efforts as well as other material data generation activities ongoing within the DoD and at the material suppliers.

The theory is that for each property a single curve can be constructed that captures the effect of the clearance. Data from this research effort will confirm this theory and/or identify the variables that alter the relationship and permit modification factors to be derived. The end results from this effort can and will be broadly applicable to the entire aerospace industry. It will permit the more rapid generation of new material property data (won't have to always test all the clearance effects) and facilitate new materials insertion.

Proposed Project – Determination of Combined Countersink & Fastener Clearance Effects

A small test matrix is included to verify that the effects of the countersink and the fastener clearance act independently and don't have any synergic interactions that would result in larger knockdowns.

ATTACHMENT

.xls file that contains proposed test matrices

- Note ~ half of this testing is already included as part of the baseline NCAMP materials characterization plan.