GENESIS

Structural Analysis and Optimization

New Features and Enhancements

Version 16.0

March 2017

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1 Executive Summary

This document describes the new and enhanced features added to *GENESIS* in version 16.0. Key enhancements include the following:

Reliability Analysis: Probability of failure of constraints can be calculated to asses reliability.

Reliability Based Optimization: Probability of failure results can be used in sizing and shape optimization to satify probabilitic constraints.

Multi-model Optimization: *GENESIS* 16.0 includes a mode that allows multiple optimization models to run simultaneously via a master optimization process. The individual sub-models may share some or all of their design variables with other sub-models. Each sub-model may include its own private constraints and objectives. Using multi-model optimization, large-scale optimization problems may be solved on HPC clusters, with each sub-model analysis solver running on a separate compute node.

Heat Transfer Topology Optimization: Elements associated to MAT4 and MAT5 can now be topologycally designed using heat transfer loadcases. A new responses is avaiable in for this type of optimization: HTC (heat transfer compliance). The existing DRESP1-TEMP response can now be used with topology data too. TRESP1 can now reference TEMP.

New Fabrication Constraints Option for Casting Constraints in Topology: Casting constraints defined with FGX, FBX, FTX, FGY, FBY, FTY,FGZ, FBZ and/or FTZ can now be used with the no-hole option. This allows the user to get optimla designs that are watertight. In the past the no-hole option was only avaiable for stamping constraints.

New von Mises Stress Response for Bar Elements Designed with DVPROP3 type CIRCLE.

Enhanced Contact Analysis: For surface to surface contact inolving shell elements, thickness is now accounted for. Now, contact and glue connection behaves similarly.

Enhanced Superelements: Strain energy in residual problems that simultaneouly have inertia relief and superelements (DMIG) are now calculated to give the same value as the full system model.

Updated DOT Optimizer: *GENESIS* now uses DOT 7.2 which is the latest version of the DOT optimizer.

2 Analysis Enhancements

1. Reliability Analysis: Non-deterministic values can now be calculated for retained constraints used in optimization. For each design variable, the user now can input one of the following variability quantities:
   - Standard deviation
   - Coefficient of variation
   - Variance

   The following non-deterministic values are now calculated and printed in the output file:
   - Standard deviation
   - Reliability
   - Probability of failure

   Solution Control Command - RELIABILITY
   Bulk Data Statements - DVAR

2. Superelement Enhancement. Now generated superelement DMIG files include extra information required to calculate the total strain energy of a residual model subjected to inertia relief. This extra information will be automatically used in the residual model when the DMIG file is included in the bulk data.

3 Structural Optimization Enhancements

1. Reliability Optimization: Probability of failure can now be constrained.
   Solution Control Command - RELIABILITY
   Bulk Data Statement - DOPT: RBOST
   Bulk Data Statements - DCONS,DCONS2

2. Multi-model Optimization: *GENESIS* 16.0 includes a mode that allows multiple optimization models to run simultaneously via a master optimization process. The individual sub-models may share some or all of their design variables with other sub-models. Each sub-model may include its own private constraints and objectives. Using multi-model optimization, large-scale optimization problems may be solved on HPC clusters, with each sub-model analysis solver running on a separate compute node.

3. Heat transfer topology optimization. Now topology variables can design heat transfer elements associated to MAT4 and MAT5.
   Bulk Data Statements -TPROP

4. Heat Transfer Compliance are now available as heat transer responses for optimization.
   Bulk Data Statements - DRESP1, TRESP1, RTYPE=HTC

5. TEMP Response: Temperatures are now available as heat transer responses for topology optimization. In the past TEMP was only available for parametric optimization.
   Bulk Data Statements - DRESP1, TRESP1, RTYPE=TEMP

6. New von Mises Stress Response for Bars Elements**:** Two stress item codes for the CIRCLE cross section of the DVPROP3 library has been re-purposed to return the maximum von Mises stress on each bar end.
   Bulk Data Statements - DRESP1, and DVPROP3 with TYPE=CIRCLE

7. New Fabrication Constraints Option for Casting Constraints in Topology: Casting constraints defined with FGX, FBX, FTX, FGY, FBY, FTY,FGZ, FBZ and/or FTZ can now be used with the no-hole option. This allows the user to get optimla designs that are watertight. In the past the no-hole option was only avaiable for stamping constraints.
   Bulk Data Statements - TSYM1, TSYM2 and TSYM3

8. Updated DOT: The latest version of the DOT optimizer, 7.2, is now available with GENESIS.

9. Enhanced Mesh Smoothing: The mesh smoothing algorithms have been adjusted to be more robust. This change should allow for larger shape changes before the mesh becomes too distorted.

10. Lua Scripting Enhancements: Lua scripts can now directly access and/or change constraint bounds through the new `genesis.dcons` function. This functionality enables access to advanced techniques, such as progressive constraint enforcement, to solve difficult problems. In addition, Lua scripts can now create charts in generated xlsx spreadsheet files.

4 Output Enhancements

1. Reliabiltity Analaysis Postprocessing File. A new punch file *RELxx.pch with probability of failure values is now available to assist visualizing reliability analsysis results.

5 New Input Data

5.1 Executive Control

MODEL	Defines the name of submodels. This data is only used in a master input file on multi-model runs.

5.2 Solution Control

RELIABILITY	Solution control command that controls the amount of information to be printed on reliability analysis.

5.3 New Analysis PARAMeters

BCSRCH	Flag to determine whether or not to account for the thickness of CQUAD4/CQUAD8/CTRIA3/CTRIA6 elements when calculating the normal distance for BCPAIR contact surfaces. 1: Default. Thickness will be accounted for. Distance is from the top surface of the element. 0: Thickness is ignored. Distance is from the element reference plane.
GLSRCH	Flag to determine whether or not to account for the thickness of CQUAD4/CQUAD8/CTRIA3/CTRIA6 elements when calculating the normal distance for CGLUE connected surfaces. 1: Default. Thickness will be accounted for. Distance is from the top or bottom surface of the element, depending on which outward normal is oriented appropriately. 0: Thickness is ignored. Distance is from the element reference plane.

5.4 New DOPT Parameters

RBOST	Parameter to control when reliability optimization starts. A value of -1 will make *GENESIS* 16.0 start the reliability optimization process after the deterministic optimization process has converged. A value of N will make *GENESIS* 16.0 start the reliability optimization process after N deterministic optimization cycles have been completed. If the deterministic optimization process finishes in M design cycles with M less than N, then the probabilistic optimization process is started in the M+1 design cycle. Default = -1.
TPQVOL	Parameter to control if the heat transfer load QVOL is affected (=1) or not (=0) by the topology design variables. Default = 1.

6 Enhanced Input Data

6.1 Bulk Data

DVAR	Now accepts variability values for reliability analsysis and optimization.
DCONS	Now accepts probabilty of failure bounds for reliability optimization.
DCONS2	Now accepts probabilty of failure bounds for reliability optimization.
TPROP	Can now reference properties (such PSOLID, PSHELL, etc) that reference MAT4 or Mat5. This enables topology optimization for heat transfer.
TPROPC	Can now reference properties (such PSOLID, PSHELL, etc) that reference MAT4 or Mat5. This enables topology optimization for heat transfer.
TSYM1	Now allows NO-HOLE option for : Filling from a general plane: FGX, FGY and FGZ Filling from bottom: FBX, FBY and FBZ Filling from top:FTX, FTY and FTZ This allows the use to get castable design that are also watertight .
TSYM2	Now allows NO-HOLE option for : Filling from a general plane: FGX, FGY and FGZ Filling from bottom: FBX, FBY and FBZ Filling from top:FTX, FTY and FTZ This allows the use to get castable design that are also watertight .
TSYM3	Now allows NO-HOLE option for : Filling from a general plane: FGX, FGY and FGZ Filling from bottom: FBX, FBY and FBZ Filling from top:FTX, FTY and FTZ This allows the use to get castable design that are also watertight .

6.2 DRESP1/TRESP1- RTYPE Enhancements

HTC	Heat transfer compliance. Now available in TRESP1 and DRESP1.
TEMP	Temperature. Now available in TRESP1.
STRESS	von Mises stresses on a bar with a circular section associated to DVPROP3 - CIRCLE can now be used as a response in optimization.

7 Enhanced Input Data Associated to Multi-Model

7.1 Executive Controls for Master Multi-Model input file

ANALYSIS
CEND
CHECK
DIAG
DRESP2
INCLUDE
IOBUFF
LENVEC
RESTART
SCRIPT
SENSITIVITY

These executive control commands, which are normally used in a regular GENESIS input data, can now be used in a MASTER input data associated to MMO (Multi-Model Optimization).

7.2 Solution Control for Master Multi-Model input file

APRINT
BEGIN BULK
DPRINT
DRESP2
ECHO
ECHOON
ECHOOFF
INCLUDE
LINE
OPRINT
SUBTITLE
TIMES
TITLE
UPRINT

These solution control commands, which are normally used in a regular GENESIS input data, can now be used in a MASTER input data associated to MMO (Multi-Model Optimization).

7.3 Bulk Data for Master Multi-Model input file

DCONS DCONS2 DEQATN DINDEX DOBJ DOPT DRESP2 DRESP3 DSCREEN DTABLE ENDDATA INCLUDE TCONS TCONS2 TINDEX TOBJ TRESP2 TRESP3	These bulk data entries, which are normally used in a regular GENESIS input data, can now be used in a MASTER input data associated to MMO (Multi-Model Optimization).

8 GENESIS Manual Updates

All *GENESIS* manuals have been updated to reflect the new features, as well as the new and modified data entries.

Manual Title	Filename	Status
GENESIS: Analysis Manual	volume1.pdf	Updated to reflect all enhanced and new features.
GENESIS: Design Manual	volume2.pdf	Updated to reflect all enhanced and new features.
GENESIS: Analysis Examples	volume3.pdf	Updated.
GENESIS: Design Examples	volume4.pdf	Updated.
GENESIS: Quick Reference Manual	quickref.pdf	Updated to reflect all changes and new data entries
GENESIS: New Features and Enhancements	newfeat.pdf	This document which describes the changes between GENESIS versions 16.0 and 15.0

9 Changes in Version 16.0 with Respect to Version 15.0

GENESIS 16.0 should run any problem that was successfully running in version 15.0 with no changes, except for the following:

The stress recovery for CBAR elements designed with the DVPROP3 CIRCLE section has changed. Item codes 1 and 6 now calculate the maximum von Mises stress on ends A and B, respectively. Optimization data using this section with those item codes will need to be changed to reproduce the prior results. Averaging the stresses of item codes 2 and 3 will return the value of the previous definition for item code 1. Similarly, stresses of item codes 7 and 8 can be averaged to calculate the value of the previous definition of item code 6.

Nonlinear contact using BCPAIR to connect surfaces from CQUAD4/CQUAD8/ CTRIA3/CTRIA6 elements may behave differently due to changes in the search algorithm. By default, *GENESIS* will now account for the thickness of the elements by calculating the normal distance from the top surface of each element instead of from the reference plane. This distance is compared to SRCHDIS to decide whether or not to create contact points, so now the total number of contact points may be different. This change also affects the calculation of the initial offset of the contact points, which controls the amount of relative displacement surfaces are allowed to undergo before being considered to be in contact. Analysis PARAMeter BCSRCH can be set to 0 to revert to the previous behavior.

By default, *GENESIS* now uses TCONS/TCONS2/TOBJ/TINDEX data even if there is no TPROP data. Previously all topology constraints and objectives were ignored if no TPROP existed. The executive control command TOPOLOGY=NO can be used to tell *GENESIS* to ignore all topology data.