GENESIS

Structural Analysis and Optimization

New Features and Enhancements

Version 13.0

January 2014

1 Introduction

This document describes the new and enhanced features added to *GENESIS* in version 13.0. Key enhancements include the following:

Nonlinear Contact Analysis: Nonlinear surface-to-surface contact conditions can now be included in static analysis loadcases. Contact force, pressure and clearance results can be printed in the output file or output to punch and/or output2 post-processing files for visualization in Design Studio for Genesis. Bulk data entries BCPAIR and BCPADD are now available to define potential contact surfaces.

Nonlinear Contact Optimization: Grid contact pressure and grid contact clearance responses from static loadcases with nonlinear contact can now be selected for use in constraints or objectives. DRESP1/TRESP1 have new response types CPRESS and CDISP to select these contact responses.

Mixed Topology and Shape/Sizing Optimization: Optimization problems may now have both topology designable regions and parametric shape/sizing/topography/ topometry designed entities at the same time. In addition, all response types from DRESP1 and TRESP1 may be used in any optimization problem setup (i.e., topology-only, parametric-only or mixed).

Frequency Response Enhancements: Enforced motion (displacement, velocity, acceleration) can now be specified by referencing SPCD from RLOAD1/2 entries. A new DLOAD bulk data entry allows easy linear combination of RLOAD1/2/3 entries. Frequency-dependent stiffness and damping properties can be specified for bushing elements with the new PBUSHT bulk data entry.

Optimization Enhancements: A new option for topometry coarsening is available. Method LENGTH divides space with a regular array based on given cell dimensions, and often results in more uniform design patches. Extended topology regions now allow topology fabrication constraints to be enforced across multiple element properties.

Composite Enhancements: Property definitions with global ply IDs may now be defined using the PCOMPG bulk data entry. Several new response types for DRESP1 specific to composites are now available. CSTRESS and CSTRAIN select the stress and strain components of individual composite layers. CTHICK provides the total composite thickness. LTHICK provides individual layer thicknesses.

Output Improvements: The new OPRINT solution control command allows control over which design cycles will produce optimization post-processing files. Multiple post-processing formats can now be selected with the POST executive control command. Output2 format files are now smaller and take less time to produce. The shape post-processing file now skips grids with zero shape change, which will frequently result in a smaller file.

2   Analysis Enhancements

1. Contact. Nonlinear surface-to-surface contact conditions can now be included in static analysis loadcases. Contact force, pressure and clearance results can be printed in the output file or output to punch and/or output2 format post-processing files for visualization in Design Studio for Genesis.

   Solution Control Commands - BCONTACT, CDISP, CFORCE, CPRESSURE

   Bulk Data Statements - BCPAIR, BCPADD

2. Enforced Periodic Motion. Enforced displacement, velocity or acceleration in can now be specified for direct and modal frequency response loadcases.

   Bulk Data Statements - RLOAD1, RLOAD2, SPCD

3. Dynamic Load Combination. A new bulk data entry allows easy linear combination of RLOAD1, RLOAD2 and RLOAD3 entries.

   Bulk Data Statement - DLOAD

4. Frequency-Dependent Bushing. Frequency-dependent stiffness and damping properties can be specified for CBUSH elements for use in direct and modal frequency response loadcases.

   Bulk Data Statement - PBUSHT

5. Composite Global Plies. Property definitions with global ply IDs may now be defined using the PCOMPG bulk data entry.

   Bulk Data Statement - PCOMPG

3 Mixed Topology, Shape, Sizing, Topometry, Topography and Freeform Optimization

1. Mixed Design Definition. Optimization problems may now have both topology designable regions and parametric shape/sizing/topography/topometry designed entities at the same time.

    Bulk Data Statements - DVAR, DVPROP1, DVPROP2, DVPROP3, DVPROP4, DVGRID, DVGRIDC, DOMAIN, DTGRID, DSPLIT, TPROP, TVAR

2. Mixed Responses. All response types from DRESP1 and TRESP1 may be used in any optimization problem setup (i.e., topology-only, parametric-only or mixed). The optimization problem definition will include all constraints. If both topology and parametric objectives are defined, they will be combined into an index objective.

    Bulk Data Statements - DRESP1, DRESP2, DRESP3, DOBJ, DINDEX, DMATCH, DMATCH2, DCONS, DCONS2, DSELECT, TRESP1, TRESP2, TRESP3, TOBJ, TINDEX, TCONS, TCONS2, TSELECT

4 Shape, Sizing, Topometry, Topography and Freeform Optimization Enhancements

1. Contact Responses. Grid contact clearance and grid contact pressure responses from nonlinear contact static loadcases are available with the CDISP and CPRESS response types on DRESP1. Contact clearance measures the separation of potential contact surfaces that are not in contact, while contact pressure measures the pressure passed between surfaces that are in contact. The responses are calculated at specified grids on potential contact surfaces.

   Bulk Data Statement - DRESP1

2. Composite Responses. Stress and strain components from individual composite layers may now be selected as responses for use in constraints or objectives. These are specified using response type CSTRESS and CSTRAIN on DRESP1. Total and individual layer thicknesses are available as convenience responses using the CTHICK and LTHICK responses types, respectively.

   Bulk Data Statement - DRESP1

3. Topometry Coarse Method. A new coarsening method is available for topometry. The LENGTH option divides space into a regular array of cells of specified dimensions. All elements in a given cell are controlled by the same design variable(s). This frequently results in more uniform design patches than the previously existing MAXELEM method.

   Bulk Data Statement - DSPLIT

4. Topometry-Sizing Combination. The same non-split variable may now be shared by two or more topometry regions, as long as it is non-split in all of them. *GENESIS* previously did not allow different topometry regions to share any design variables.

   Bulk Data Statement - DSPLIT

5 Topology Optimization Enhancements

1. Extended Topology Regions. Topology fabrication constraints can now be enforced across multiple element properties by creating extended topology regions.

   Bulk Data Statement - TPROP

2. Contact Responses. Grid contact clearance and grid contact pressure responses from nonlinear contact static loadcases are available with the CDISP and CPRESS response types on TRESP1. Contact clearance measures the separation of potential contact surfaces that are not in contact, while contact pressure measures the pressure passed between surfaces that are in contact. The responses are calculated at specified grids on potential contact surfaces.

   Bulk Data Statement - TRESP1

6   Output Enhancements

1. Loadcase Titles and Subtitles. Previously, *GENESIS* would only read one global title and subtitle. Now each loadcase can have its own title and/or subtitle, improving the identification of results in output and post-processing files.

    Solution Control Commands - TITLE, SUBTITLE

2. Multiple Post Formats. Now multiple post-processing formats may be specified. A different post-processing file will be created for each format. All analysis post output requests will write results to every file.

    Executive Control Command - POST

3. Optimization Post File Control. Now it is possible to reduce file system usage by limiting which design cycles will write optimization post-processing files. The new OPRINT command functions in a similar manner to the previously existing APRINT and DPRINT commands to choose which cycles will write optimization post results. Optimization post-processing files are requested by the DENSITY, SIZING and/or SHAPE solution control commands.

    Solution Control Command - OPRINT

4. Reduced Output2 Filesize. Output2 formatted post-processing files now use record buffering to substantially reduce the physical filesize required to hold the records. A side-effect of this reduction makes the creation of these post-processing files significantly faster.

5. Improved Shape File. In most typical cases, the shape post-processing file (*.SHP) will be smaller due to the fact that grids with zero shape change are now omitted.

    Solution Control Command - SHAPE

7 New Input Data

7.1 Solution Control

BCONTACT   Select surface pairs for nonlinear contact analysis.

CDISP   Request contact clearance result output.

CFORCE   Request contact force result output.

CPRESSURE   Request contact pressure result output.

OPRINT   Control which design cycles will produce optimization post-processing files.

7.2 Bulk Data

BCPADD   Create a union of potential contact pair sets.

BCPAIR   Create a potential contact pair for nonlinear contact analysis.

DLOAD   Creates a linear combination of RLOAD1/RLOAD2/RLOAD3 entries.

PBUSHT   Add frequency-dependent stiffness and/or damping data to a PBUSH property.

PCOMPG   Create a composite property with global ply IDs.

8 Enhanced Input Data

8.1 Executive Control

POST   Multiple post-processing formats can be specified.

TOPOLOGY   Now disables mixing of topology with shape/sizing/topography/topometry optimization.

8.2 Solution Control

SUBTITLE   Can specify different subtitles for different loadcases.

TITLE   Can specify different titles for different loadcases.

8.3 Bulk Data

DRESP1   Can accept new responses (CDISP, CPRESS, CSTRAIN, CSTRESS, CTHICK and LTHICK).

DSPLIT   Can use coarse method LENGTH.

RLOAD1   Can reference SPCD for enforced displacement, velocity or acceleration. Can be referenced by DLOAD bulk data.

RLOAD2   Can reference SPCD for enforced displacement, velocity or acceleration. Can be referenced by DLOAD bulk data.

RLOAD3   Can be referenced by DLOAD bulk data.

SPCD   Can be referenced by RLOAD1/RLOAD2

TPROP   Format change to specify the property type and move the rule type to a RULE continuation line. Introduces a new PLINK continuation to create an extended topology region. Note: Old TPROP format is still supported.

TRESP1   Can accept new responses (CDISP, CPRESS)

8.4 DRESP1- RTYPE Enhancements

CDISP   Selects contact clearance.

CPRESS   Selects contact pressure.

CSTRAIN   Selects composite layer strain.

CSTRESS   Selects composite layer stress.

CTHICK   Selects composite total thickness.

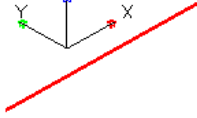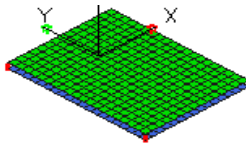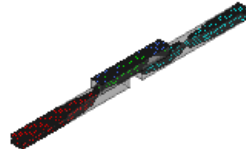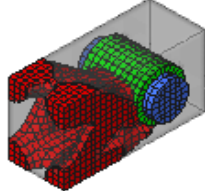LTHICK   Selects composite layer thickness.

8.5   TRESP1- RTYPE Enhancements
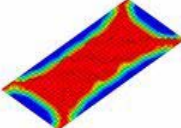
CDISP   Selects contact clearance.

CPRESS   Selects contact pressure.

9 New Example Problems

The following table describes new examples and their corresponding input file names. The listed files are provided with the installation

Name	Problem	Special Features	Figure
A047.dat	Enforced Dynamic Displacement using RLOAD1	Enhancement of RLOAD1. Dynamic displacements, velocities and accelerations can be enforced by referencing SPCD data on RLOAD1/RLOAD2 card	
A048.dat	Point FRF of two rectangular plates connected by CBUSH elements	Use of new frequency dependent generalized elastic element property PBUSHT	
T025.dat	Topology Optimization with Contact Analysis and Glue Connection	Contact and Glue surfaces are specified using BSURFE, BCPAIR and CGLUE data. Use of BCONTACT and NLPARM solution control commands.	
T026.dat	Topology Optimization with Contact Pressure response	Contact surfaced specified using BSURFP and BCPAIR. TRESP1 data entry for contact pressure constraint. Use of BCONTACT and NLPARM solution control commands.	
T027.dat	Topology Optimization with Force Constraints in CELAS connectors	Force constraints on elastic elements connecting two regions are enforced with DRESP1 and DCONS.	

M001.dat	Shape and Topology Optimization of a Hat Structure	Combined Shape and Topology optimization	
M002.dat	Sizing and Topology Optimization of a Hat Structure	Combined Sizing and Topology optimization	
M003.dat	Freeform and Topology Optimization of a Rectangular plate	Combined Freeform and Topology optimization	
M004.dat	Shape and Topology Optimization of a Curved Shell	Combined Shape and Topology optimization	

The last four new examples are also provided with the step-by-step sample manual of Design Studio. The Design Studio step-by-step sample manual also has additional new examples.

10 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 improved and new features
GENESIS: Design Manual	volume2.pdf	Updated to reflect all improved 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

11 Changes in Version 13.0 with Respect to Version 12.2

GENESIS 13.0 should run any problem that was successfully running in version 12.2 with no changes, except for the following.

GENESIS now supports mixing topology and parametric shape/sizing/topometry/ topology data in the same optimization problem. Previously, if an input file included both topology and parametric data, the topology data would be ignored.

The format of grid stress records in punch and output2 formatted post-processing files is different from previous versions. The new format is expected to be compatible with most third-party post-processors. However, previous versions of Design Studio for Genesis (before Design Studio 13.0) do not support the new format.