GENESIS

Structural Analysis and Optimization

New Features and Enhancements

Version 17.0

May 2018

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1 Executive Summary

This document describes the new and enhanced features included in *GENESIS* version 17.0. A summary of the key new features and enhancements included is the following:

Eigensolution of Fluid Meshes: The eigenvalues and eigenvectors of fluid meshes can now be calculated and used for modal frequency response analysis.

Interior Acoustic Analysis: Direct and modal frequency response analysis can now be used to solve coupled fluid-structure interaction problems. New fluid elements allows the user to model fluid regions.

New Global von Mises Stress Response: A new response type, VMINDEX, is now available for DRESP1 and TRESP1. VMINDEX can be used to economically and efficiently impose von Mises stress constraints in topology and other types of optimization.

New von Mises Stress results for Random Response Analysis: The power spectral density values (PSD) and the root mean square values (RMS) associated to solid and shell elements stresses are now available as analysis results . These new results can be printed in the output file and in the punch post-processing file.

Existing Random Stresses and new von Mises Stress Response for Random Response Optimization: The power spectral density values (PSD) and the root mean square values (RMS) associated to solid and shell elements are now available as responses on DRESP1 for use in optimization. PSD results (PSDSTR) and the RMS results (RMSSTR) are available to be used as objective or constraints. These new responses are compatible with all types of optimization (shape, sizing, topology, etc.).

Progressive Topology Optimization: A new method to progressively change the power rule that connects topology design variables to element stiffnesses has been added. The new method can be controlled with the DOPT parameter TCYCLEM. This new method can be further refined using the new TCYCLE bulk data entry and the new DOPT parameters DESMAXM, CONVTD and CONVTS.

New Alternative Method for Topology Optimization: A new method for associating topology design variables to elements, named the Hybrid method, can result in more sharp and more polarized topology answers. This new method can be activated using the new DOPT parameter POLEM. This new method can also be used together with the new progressive method.

Fully Discretize Topology Optimization Results: An option to perform an additional final design cycle in topology, wherein all design variables are fully polaraized to 0.0 or 1.0 has been added. The option is controlled by a new DOPT parameters TOPDIS and TOPDISM.

New CMBDOT Optimizer: A new special purpose optimizer to solve discrete or discrete/continuous variable optimization problems has been added.

Heat Transfer Input Data Alternatives: New data entries CHBDYE, CHBDYG, CHBDYP, BDYOR, CONV and PCONV increase compatibility with third-party preprocessors capable of generating Nastran-style data.

Scalar Element Input Alternatives: New data entries CELAS3, CELAS4, CMASS3, CMASS4, CDAMP3 and CDAMP4 define stiffness, mass and damping connected to SPOINTs for further compatibility with third-party Nastran-supporting preprocessors.

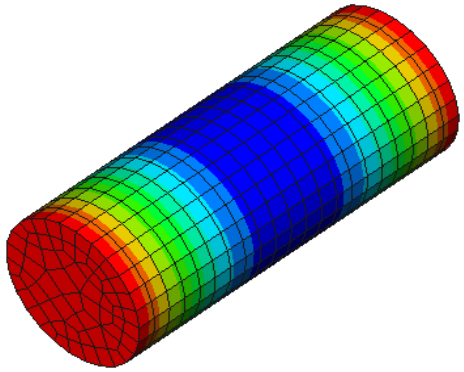
Tolerance for Badly Shaped Solid Elements: Second order elements that are flat or near flat are allowed in the model. When finding such elements, the software will ignore them.

Contact/Glue Input Conversion: Some forms of third party input data associated to contact and glue connections (SURF, TIE and CONTACT) are read and automatically converted to equivalent *GENESIS* data. However, the use of undocumented input data remains unsupported, and results of models using undocumented input data should be examined closely to ensure the model is behaving as expected.

2 Analysis Enhancements

1. Eigensolution of Fluid Meshes: The eigenvalues and eigenvectors associated to a fluid mesh can now be calculated.

   Solution Control Data Statement - METHOD(FLUID)



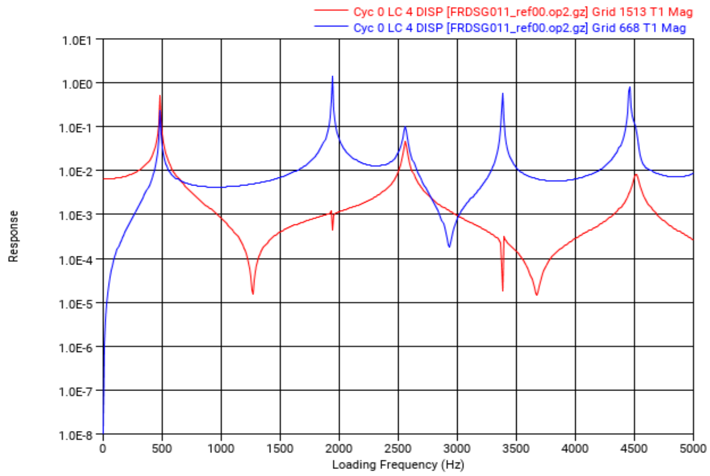
Acoustic First Mode

2. Interior Acoustic Analysis: Coupled fluid-structure frequency responses analysis can now be performed.

   Solution Control - METHOD(FLUID), METHOD(STRUCTURE)
   Bulk Data - GRID, PSOLID, MAT10
   PARAM - GFL

   The fluid mesh can use the following elements:

   - CHEXA (MAT10)
   - CHEX20 (MAT10)
   - CPENTA (MAT10)
   - CPYRA (MAT10)
   - CTETRA (MAT10)



Displacement (red) & Pressure (blue) Responses versus Loading Frequencies

3. New data entries available for static and dynamic problems:
   Bulk Data Entries - CELAS3, CELAS4, CMASS3, CMASS4, CDAMP3, and CDAMP4

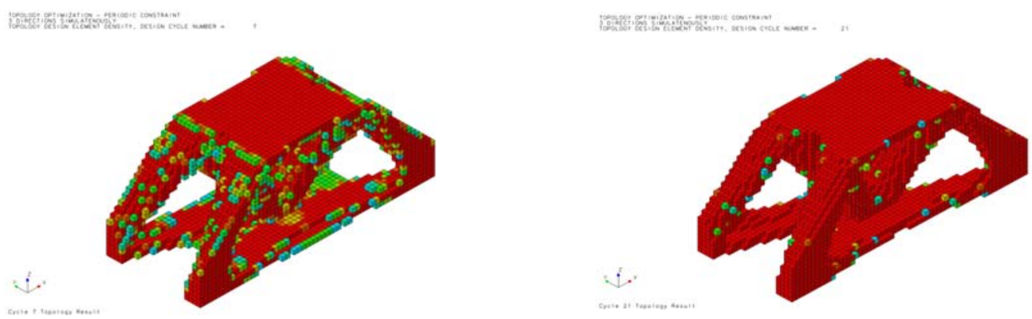
4. New data entries available for heat transfer analysis
   Bulk Data Entries - CHBDYE, CHBDYG, CHBDYP, CONV and PCONV

3 Structural Optimization Enhancements

1. New Progressive Rule for Topology Optimization: A new method to progressively change the topology design variables has been added. This method allows to have more polarized topology answers.

   Bulk Data Statements - TCYCLE

   DOPT Parameters - TCYCLEM, DESMAXM, CONVTD and CONVTS



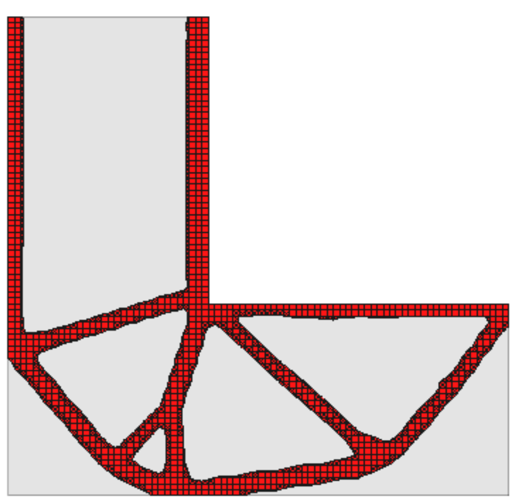
Standard Rule (left) vs Progressive Rule (right)

2. New Hybrid Method for Topology Optimization: A new method named Hybrid method allows the user to get more sharp and more polarized answers.

   DOPT Parameters - POLEM

3. New Global von Mises Stress Response: The new VMINDEX response available for DRESP1 and TRESP1 allows its user to economically and efficient impose von mises stress constraints in topology and other types of optimization.

   Bulk Data Statements - DRESP1/TRESP, new RTYPE=VMINDEX



Topology Optimization results using stress constraints

4. Random Stress Responses are now available for optimization: The Power Spectral Density (PSD) stresses and the Root Mean Square (RMS) stress responses are now available for all shell and solid elements. The type of stresses are all stress tensor components (Normal-x, Normal-y, Shear xy, etc) and the von Mises stress.

   Bulk Data Statements - DRESP1, new RTYPE=PSDSTR and RMSSTR

```
CONSTRAINT

                       RANDOM RMS STRESS
 ---------------------------------------------------------------------------
                              LOADCASE      RESPONSE    BOUND   BOUND      BOUND
            ELEM ID ITEM     ID    FREQ  VALUE       TYPE    VALUE      STATUS
 ---------------------------------------------------------------------------
 QUAD4            1    5          1    1  4.310528E+00 UB    5.047076E+00    I
 QUAD4           21    5          1    1  4.753688E+00 UB    5.047076E+00    A
 QUAD4           31    5          1    1  4.584414E+00 UB    5.047076E+00    A
 QUAD4           21    2          1    1  4.494642E+00 UB    4.773558E+00    A
 QUAD4           22    2          1    1  4.337097E+00 UB    4.773558E+00    A
 QUAD4           32    2          1    1  4.324027E+00 UB    4.773558E+00    A
 HEXA            71    1          1    1  1.557779E+00 UB    1.723278E+00    A
 HEXA            81    1          1    1  1.563391E+00 UB    1.723278E+00    A
 HEXA            91    1          1    1  1.572304E+00 UB    1.723278E+00    A
 HEXA            62    7          1    1  1.472114E+00 UB    1.557825E+00    A
 HEXA            82    7          1    1  1.472271E+00 UB    1.557825E+00    A
 HEXA            92    7          1    1  1.475317E+00 UB    1.557825E+00    A
```

5. New Reciprocal response available for shifted Responses:

	FTYPE = RECIP
ETYPE = 1	$S(f) = \text{Coeff} \times \frac{\text{Refval}}{H(f)} - T(f)$
ETYPE = 2	$S(f) = \frac{\text{Coeff} \times \frac{\text{Refval}}{H(f)}}{T(f)}$

   Bulk Data Statements - DSHIFT, new FTYPE=RECIP

6. New Parameter to Fully Discretize Topology Optimization results: The new parameter name is TOPDIS, the also new TOPDISM parameter allows the user to select criteria of discretization (by density level or by Youngs modulus level).

7. New CMBDOT Optimizer: A new special purpose optimizer to solver discrete or discrete/continuous variable optimization problems has been added.

   Bulk Data Statements - DOPT, new value for DSCDOT parameter: 2
   Bulk Data Statements - DOPT, new parameter: MAXDPG

4 Output Enhancements

1. Random von Mises Stress analysis results are now calculated and printed. The Power Spectral Density (PSD) stresses and the Root Mean Square (RMS) of the von Mises stress are now printed in the output file and in the punch file. This is available for all shell and solid elements.

ELEMENT-ID = 3939

S T R E S S E S   I N   Q U A D R I L A T E R A L   E L E M E N T S

(POWER SPECTRAL DENSITY FUNCTION)

FREQUENCY	FB	SX	SY	SXY	VMS
	FB	SX	SY	SXY	VMS
1.000000E+01	-1.000000E+00	4.904288E+06	1.358812E+03	2.810900E+04	5.071608E+06
	1.000000E+00	4.904288E+06	1.358812E+03	2.810900E+04	5.071608E+06
1.090000E+01	-1.000000E+00	7.552599E+06	2.092569E+03	4.328783E+04	7.810271E+06
	1.000000E+00	7.552599E+06	2.092569E+03	4.328783E+04	7.810271E+06
1.180000E+01	-1.000000E+00	1.020092E+07	2.826328E+03	5.846670E+04	1.054894E+07
	1.000000E+00	1.020092E+07	2.826328E+03	5.846670E+04	1.054894E+07
1.270000E+01	-1.000000E+00	1.284924E+07	3.560089E+03	7.364560E+04	1.328762E+07

RANDOM 3

S T R E S S E S   I N   Q U A D R I L A T E R A L   E L E M E N T S

(ROOT MEAN SQUARE)

ELEMENT-ID	LOC	SX	SY	SXY	VMS
	LOC	SX	SY	SXY	VMS
3175	-1.000000E+00	4.671154E+03	1.245214E+05	1.452401E+04	1.293905E+05
	1.000000E+00	4.671154E+03	1.245214E+05	1.452401E+04	1.293905E+05
3183	-1.000000E+00	1.678972E+04	7.286065E+04	2.799378E+03	8.268851E+04
	1.000000E+00	1.678972E+04	7.286065E+04	2.799378E+03	8.268851E+04
3188	-1.000000E+00	1.724327E+04	8.138053E+04	1.916795E+03	9.129299E+04
	1.000000E+00	1.724327E+04	8.138053E+04	1.916795E+03	9.129299E+04
3193	-1.000000E+00	1.395714E+04	7.911606E+04	9.774216E+01	8.693915E+04
	1.000000E+00	1.395714E+04	7.911606E+04	9.774216E+01	8.693915E+04

2. Sensitivities of the new PSDSTR and RMSTR responses can now be printed together with other sensitivities:

3. Eigenvalues for fluid meshes are now calculated and printed.

4. Pressures in the new fluid mesh can now be printed in the output file.

5 Post Processing File Enhancements

1. Random von Mises Stress analysis results are now available in the punch file. The Power Spectral Density (PSD) stresses and the Root Mean Square (RMS) of the von Mises stress are now printed in the punch file. This is available for all shell and solid elements.

2. Post-processing file naming has been improved to handle larger design cycle numbers. Now when the design cycle exceeds 99, the xx in filename patterns changes to =xxxx=. The bracketing “=” characters allow post-processors to both identify when the new pattern is used and distinguish the cycle number from the pname.

3. Topology density result files (pnameDENSxx.ext) are now written faster, especially when the model contains many types of elements.

6 New Input Data

6.1 Solution Control

AUTOSPC	Sets parameters to control automatic single point constraints for low stiffness degrees of freedom. This is an alternative to PARAM, AUTOSPC

6.2 New Bulk Data for Analysis

CELAS3	Alternative format for the CELAS1 entry for referencing SPOINT
CELAS4	Alternative format for the CELAS2 entry for referencing SPOINT
CDAMP3	Alternative format for the CDAMP1 entry for referencing SPOINT
CDAMP4	Alternative format for the CDAMP2 entry for referencing SPOINT
CMASS3	Alternative format for the CMASS1 entry for referencing SPOINT
CMASS4	Alternative format for the CMASS2 entry for referencing SPOINT
CHBDYE	Alternative CHBDY definition referencing elastic element.
CHBDYG	Alternative CHBDY definition referencing grids.
CHBDYP	Alternative CHBDY definition referencing a property.
BDYOR	Default values for CHBDYG and CHBDYP
CONV	Defines a convection condition on a heat boundary element connection CHBDYE, CHBDYG or CHBDYP
PCONV	Defines the property for convection boundary condition
MAT10	Defines the fluid material properties for elements

6.3 New Bulk Data for Optimization

TCYCLE	New entry for new topology progressive rule definition

6.4 New Analysis PARAMeters

BUSHSTIF	Maximum allowable stiffness on CBUSH elements.
DUPTOL	Coordinate tolerance for allowable duplicate GRID entries.
ELASSTIF	Maximum allowable stiffness on CELASi elements.
GFL	Damping coefficient applied to the fluid global “stiffness” matrix.

6.5 New DOPT Parameters for non-Topology Optimization

IZGRAD	A value of 0 will cause GENESIS to use zero gradient constraints in the same way as regular constraints. A value of 1 will cause GENESIS to ignore constraints that have zero gradient and that are violated. A value of 2 will cause GENESIS to ignore constraints that have zero gradient regardless if they are violated or not.
MAXDPG	Parameter for new CMBDOT discrete variable optimizer. Max number of discrete variables in a segment. The larger MAXDPG is the larger the number of function call CMBDOT will make. Unless function evaluations are very inexpensive it is recommend to not exceed 10.

6.6 New DOPT Parameters used in Topology Optimization

TCYCLEM	A value of 0 will cause *GENESIS* to ignore the progressive rule. A value of 1 will cause *GENESIS* to use the progressive rule. A negative value (between -1 and -6) will cause *GENESIS* to use a built-in progressive rule.
DESMAXM	A value of 1 will cause *GENESIS* to override DESMAX with the number of design cycles needed to complete the progressive rule schedule. A value of 0 will cause *GENESIS* to use DESMAX as the maximum number of design cycles and ignored the maximum number of design cycles needed by the progressive rule schedule. If DESMAX exists, the defaults for DESMAXM is 0. If DESMAX does not exist and the progressive rule is used then the default is 1.
CONVTD	Allowable change in the grey fraction for grey convergence. If the change in the grey fraction value in two consecutive design cycles, occurring in the last schedule of progressive power rule, is less than CONVTD, then terminate the design process with grey convergence. This parameter is only used with the progressive rule. Grey fraction is the number of elements with intermediate density values divided by the total number of topology designable elements.
CONVTS	Allowable change in the grey fraction for grey convergence. If the change in the grey fraction value in two consecutive segments is less than CONVTS, then terminate the design process with grey convergence. This parameter is only used with the progressive rule. Grey fraction is the number of elements with intermediate density values divided by the total number of topology designable elements.

POLEM	A value of 1 on POLEM will cause *GENESIS* to choose the hybrid based topology method over the geometry based topology method. A value of 0 will cause *GENESIS* to choose the geometry based topology method over the hybrid based topology method. The geometry based or hybrid based topology methods are available when minimum member size is used in TSYM1, TSYM2 or TSYM3. If minimum member size is not used, then the element based topology method is used and this parameter is ignored.
TOPDIS	A value greater than 0.0 will cause *GENESIS* to perform one additional design cycle where all topology design variables are fully polarized. Topology design variables which values are higher than TOPVAL will be set to 1.0, the rest of the topology variables will be set to its lower value (typically 0.0). If the DOPT parameter TOPDISM is 0 (or blank), then TOPVAL is TOPDIS. If TOPDISM is 1then TOVAL = TOPDIS**(1/RV1), where RV1 is the power rule.
TOPDISM	TOPDISM parameter to decide whether TOPDIS represent densities or Young’s modulus fraction. A value of 0 of TOPDISM will cause GENESIS to use TOPDIS as the density cutoff value. A value of 1 of TOPDISM will cause GENESIS to use TOPDIS as a Young’s modulus cut-off value.

7 Enhanced Input Data

7.1 Solution Control

LABEL	The “=” separator is now optional.
LOADCASE	Previously, loadcase IDs had to be defined in ascending order, and all heat transfer loadcases had to be defined before all other loadcase types. Now IDs can be defined in arbitrary order, and heat transfer loadcases can be intermixed with other loadcase types.
METHOD	Can now be used to select a method for eigenvalue calculation for fluids: METHOD(FLUID) or METHOD(STRUCTURE).
SUBTITLE	The “=” separator is now optional.
TITLE	The “=” separator is now optional.

7.2 Bulk Data

CHEXA	Can now reference fluid grids to be used as an acoustic element
CHEX20	Can now reference fluid grids to be used as an acoustic element
CPENTA	Can now reference fluid grids to be used as an acoustic element
CPYRA	Can now reference fluid grids to be used as an acoustic element
CTETRA	Can now reference fluid grids to be used as an acoustic element
GRID	Can now be used to define a fluid mesh (value of -1 in CD field). Also, certain input field values can be replicated/incremented from the previous GRID entry using “=” or “*(*x*)”.
DRESP2	Now accepts “THRU” in DVAR and DRESP1 lists.
DRESP3	Now accepts “THRU” in DVAR and DRESP1 lists.
DSELECT	Now accepts “THRU” in DVAR lists.
DSHIFT	Now accepts new type: RECIP, to create reciprocal frequency responses
PSOLID	Can now reference MAT10 when “PFLUID” is in the FCTN field
TRESP2	Now accepts “THRU” in TVAR and TRESP1 lists.
TRESP3	Now accepts “THRU” in TVAR and TRESP1 lists.
TSELECT	Now accepts “THRU” in TVAR and PROP lists.

7.3 DRESP1/TRESP1- New response types RTYPE

VMINDEX	Global von Mises Stress Index. Now available in TRESP1 and DRESP1
PSDSTR	Power Spectral Density Random Stresses. Now available in DRESP1
RMSSTR	Root Mean Square Random Stresses. Now available in DRESP1

7.4 New option of existing DOPT Parameters

DSCDOT	Now can be used to activate the new CMBDOT optimizer. A value of 2 will turn on CMBDOT.

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 17.0

9 Changes in Version 17.0 with Respect to Version 16.0

GENESIS 17.0 should run any problem that was successfully running in version 16.0 with no changes.