GENESIS

Structural Analysis and Optimization

New Features and Enhancements

Version 10.0

May 2008

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1 Introduction

This document describes the new and enhanced features added to Genesis in version 10.0.

Genesis has been improved to support shared-memory parallel computers. With this new capability Genesis solvers can now run faster on SMP computers. In one example using 4 CPUs, the SMS eigenvalue solver in Genesis solved an eigenvalue problem 2.5 times faster than using 1 CPU.

Extended topometry regions have been added to Genesis. This capability allows multiple set of properties to be topometrically optimized using one DSPLIT. This capability allows global symmetries rather than just local ones.

Fabrication constraints are now available for topography optimization. Now you can use mirror, cyclic and/or extrusion constraints to obtain more manufacturable designs.

Existing fabrication constraints in topology have been extended to allow you to design stamped sheet structures. The new sheet forming constraints can be used together with existing mirror and cyclic symmetry in the same region. The new sheet forming constraints allow you to request 1 or 2 layers of material. The layers can be solid or allow holes punched through. The layers can have a constant user specified thickness. This capability, unique to Genesis, can help you get topology answers that are easier to manufacture.

Superelement stiffness and mass matrices are now designable in Genesis. This capability can be used to select between alternative components.

Two new experimental optimizers has been added to Genesis: STRDOT and DSCDOT. The first optimizer is for problems that have large number of design variables and large number of active stress constraints. The second optimizer is for problem with discrete variables.

2 Analysis Enhancements

1. The program can use now multiple processors on shared-memory parallel computers.
   Executive Control Command - THREADS

2. Input/output of Genesis has been improved by adding memory buffers. The size and number of the buffers can be controlled by the user.
   Executive Control Command - IOBUFF

3. The latest version of SMS is available with this version. This version has been changed to use multiple processors.
   Bulk Data Statement - EIGR, SMS option

4. Automatic inertial relief
   Solution Control Data - SUPORT = AUTO
   Bulk Data Statement - PARAM, INREL

5. New elastic element: Gap element
   Bulk Data Statement - CGAP
   Bulk Data Statement - PGAP

6. New alternative command to specify superlement stiffness. This new entry includes a stiffness multiplier property ID for the superlement.
   Executive Control Command - K2UU1
   Bulk Data Statement - PK2UU

7. New alternative command to specify superlement mass. This new entry includes a mass multiplier property ID for the superlement.
   Executive Control Command - M2UU1
   Bulk Data Statement - MK2UU

8. User-supplied stress based failure indices for composites (alternative to Hill, Hoffman or Tsai-Wu).
   Bulk Data Statement - PCOMP (Field 6 now can also reference a FINDEX entry)
   Bulk Data Statement - FINDEX

9. User-supplied strain based failure indices for composites (alternative to Max Strain).
   Bulk Data Statement - PCOMP (Field 6 now can also reference a FINDEXN entry)
   Bulk Data Statement - FINDEXN

10. New alternative command to specify nonstructural mass for PROD, PBAR, PBARL, PBEAM, PBEAML, PSHEAR, PSHELL and PCOMP.
    Executive Control Command - NSM
    Bulk Data Statement - NSM, NSM1, NSML, NSML1, NSMADD

3 New Optimizers and Approximation Methods

1. The new DSCDOT optimizer has been added. This optimizer can be used to solve problems with discrete or mixed (discrete and continuous) design variables.

   Bulk Data Statement - DOPT,DSCDOT

2. The new STRDOT optimizer has been added. This optimizer can be used to solve problems with large number of stress constraints and large number of design variables.

   Bulk Data Statement - DOPT,STRDOT
   Bulk Data Statement - DOPT,ISDMAX

3. A new force approximation is now available for responses that used the force approximation method (failure indices, stress, strains and the forces themselves). With this new approximation, the sensitivity module requires much less in-core memory and now is extremely fast. However, the old approximation is the defaults as it is in general more accurate. This new methods works well for problems with very large number of stress constraints and design variables. This new method is the default when the STRDOT optimizer is used. The STRDOT optimizer does not require this new method.

   Bulk Data Statement - DOPT,RCOMPAPP (for composites elements)
   Bulk Data Statement - DOPT,RSHLAPP (for shell elements)

4 Shape, Sizing, Topometry and Topography Optimization Enhancements

1. Extended topometry regions capabilities have been added to DSPLIT. With this capability, multiple properties can be referenced by a single DSPLIT entry. This allows global symmetries and easily applying the same type of manufacturing constraints to elements associated to properties of same the type but with different PIDs.

   Bulk Data Statement - DSPLIT (PLINK optional continuation line)

2. Optional composite layer angle symmetry has been added to DSPLIT. With this capability, angles designed by topometry optimization and symmetries can be forced to be symmetric. This new option is now the default when designing angles in topometry optimization. Angles can optionally be replicated instead (old method).

   Bulk Data Statement - DSPLIT (ANGREP field of the SYM optional continuation line)

3. Fabrication constraints are now available for topography optimization. Mirror, cyclic and extrusion constraints to are available to obtain more manufacturable design proposals.

   Bulk Data Statement - DTGRID (SYM optional continuation line)

4. User supplied stiffness matrices, specified with the new alternative executive control command K2UU1 and then new bulk data entry PK2UU can now be designed with sizing and topometry.

   Bulk Data Statement - DVPROP1->PK2UU
   Bulk Data Statement - DVPROP2->PK2UU

5. User supplied mass matrices, specified with the new alternative executive control command M2UU1 and then new bulk data entry PM2UU can now be designed with sizing and topometry.

   Bulk Data Statement - DVPROP1->PM2UU
   Bulk Data Statement - DVPROP2->PM2UU

6. PCOMP entries that reference the new user supplied failure indices FINDEX or FINDEXN entries can be referenced by DRESP1. In other words, the user supplied failure indices can be used in the same way as standard failure indices in optimization.

   Bulk Data Statement - DRESP1->PCOMP->FINDEX
   Bulk Data Statement - DRESP1->PCOMP->FINDEXN

7. Multiple DTABLE data entries are allowed. In the past only one DTABLE entry was allowed.

   Bulk Data Statement - DTABLE

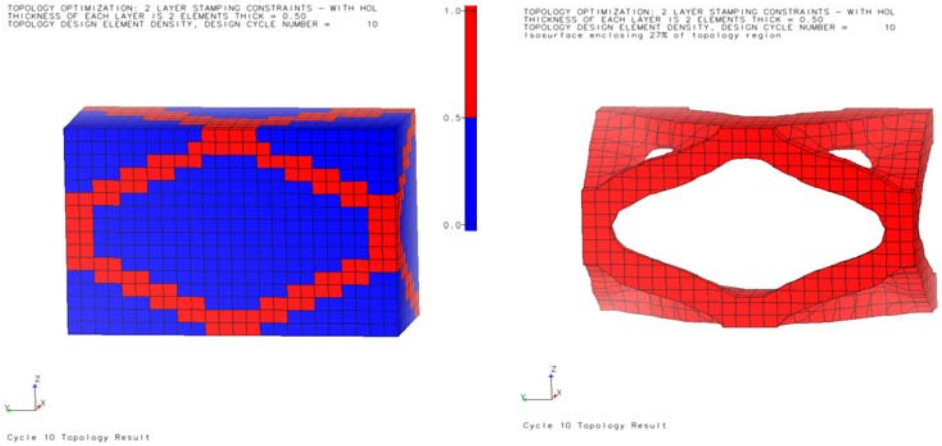
5 Topology Optimization Enhancements

1. New fabrication constraints to obtain stamped sheet structures have been added. These new fabrication constraints can be mixed with mirror and cyclic symmetries. Symmetric constraints, when used with this new fabrication constraints, allow the enforcement symmetries in structures even when the finite element mesh is not symmetric.

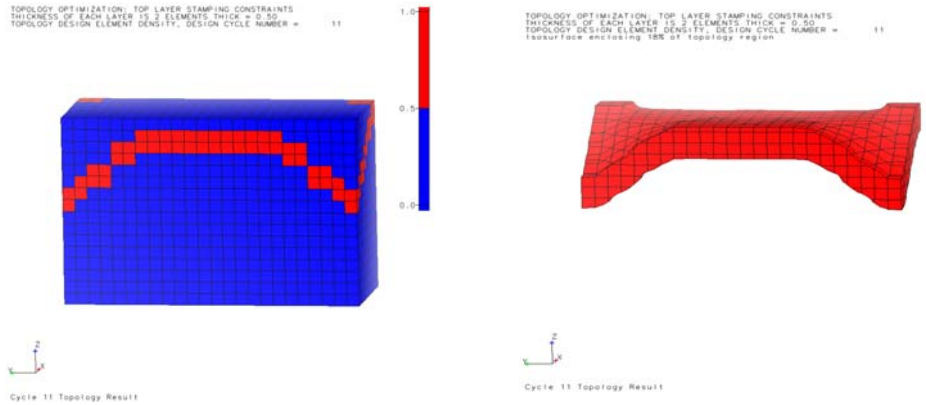
   Bulk Data Statement - TSYM1, TSYM2, TSYM3

   New Types- STX, STY, STZ, SBX, SBY, SBZ, S2X, S2Y and S2Z

The following figure shows results of topology optimization run with a two layers option. Each section of the structure has uniform thickness. Holes punched through the sheets were allowed and are shown in the results. The example shown here is T019.dat and is included on the installation CD.



The following figure shows results of topology optimization run with a one layer option. Punched holes optional were not allowed in this example. The example shown here is T021.dat and is included on the installation CD.



6 Overall Optimization Enhancements

1. Restarting from incomplete history files, *pname*.HIS, is now allowed. Now history files do not have to contain all design cycles. This allows the user to reduce the size of the history file, to a fraction of its total size. The reduced file has to have all data for the kept design cycles.For example, all design variables corresponding to the last design cycle and their corresponding objective function information.

   Bulk Data Statement - DOPT,DVARHIS

7 Output Enhancements

1. Now the printing of the *pname*.DNS topology density file can be controlled. This file will no longer be printed by default, as the *pname*DENS*xx*.*ext* files are usually much more convenient to work with.

   Bulk Data Statement - DOPT, DNSHIS

2. Now the printing of the *pname*.OPT file can be controlled. This file will no longer be printed by default, as the *pname*UPDATE*xx*.dat files serve a similar purpose, and are usually much more convenient to work with.

   Bulk Data Statement - DOPT, OPTHIS

3. To reduce the size of the output file, the printing of repeated warning messages has been reduced to 10 per message type. A summary of the total number of warnings of each type is now printed in the bottom of the output file.

   Bulk Data Statement - DIAG=111 (force GENESIS to print all messages)

8 New Input Data

8.1 Executive Control

THREADS	Defines the number of threads used on a parallel machine. Default=1.
IOBUFF	Defines the size and number of the I/O buffers.
K2UU1	Selects a file containing a user defined stiffness matrix and references a PK2UU property.
M2UU1	Selects a file containing a user defined stiffness matrix and references a PM2UU property.

8.2 Solution Control

NSM	Selects a set of nonstructural mass referencing the new NSM, NSM1, NSML, NSML1 and NSMADD bulk data entries

8.3 Bulk Data

CGAP	Defines a linear Gap element.
FINDEX	Stress based user-supplied failure index for composite elements.
FINDEXN	Strain based user-supplied failure index for composite elements.
NSMADD	Defines a nonstructural mass set as the union of nonstructural mass sets defined by NSM, NSM1, NSML and NSML1.
NSM	Defines a nonstructural mass per property ID. Adds NSM to the following property types: PSHELL, PCOMP, PSHEAR, PBEAM, PBEAML, PBAR, PBARL and PROD.
NSM1	Alternative form for NSM.
NSML	Defines a lumped nonstructural mass per property ID. Adds NSM to the following property types: PSHELL, PCOMP, PSHEAR, PBEAM, PBEAML, PBAR, PBARL and PROD. The lumped mass is divided on the corresponding element according to their sizes (area or length).
NSML1	Alternative form for NSML.
PGAP	Defines properties for the linear Gap element.
PK2UU	Defines properties for the K2UU1 superelement.
PM2UU	Defines properties for the M2UU1 superelement.

8.4 New Analysis Parameters

INREL	Inertia relief parameter.
T6TOT3	Read CTRIA6 as CTRIA3 elements.

8.5 New Design Parameters

DNSHIS	Controls the printing of the *pname*.DNS file. A value of 1 will cause the program to print the *pname*.DNS file. A value of 0 will cause the program to not print the *pname*.DNS file.
DSCDOT	Parameter to control which optimizer is used for discrete variable optimization. If DSCDOT = 0, the program will use BIGDOT. If DSCDOT = 1,the program will use the new DSCDOT optimizer.
DVARHIS	Controls allowing using partial history (*pname*.HIS) files.
ISDMAX	The maximum number of STRDOT design cycles.
OPTHIS	Controls the printing of the *pname*.OPT file. A value of 1 will cause the program to print the *pname*.OPT file. A value of 0 will cause the program to not print the *pname*.OPT file.
RCOMPAPP	Switch for shell element forces approximations. If RCOMPAPP=0, the program will use the standard force approximations.If RCOMPAPP=1, the program will use a special fast approximation. The default is 0 except when the STRDOT optimizer is used in which case the default is 1.
RSHLAPP	Switch for shell element forces approximations. If RSHLAPP=0, the program will use the standard force approximations.If RSHLAPP=1, the program will use a special fast approximation. The default is 0 except when the STRDOT optimizer is used in which case the default is 1.
STRDOT	The STRDOT parameter is used to control the use of the STRDOT optimizer. If STRDOT=0, the program will not use the STRDOT optimizer. If ISRMET = -1 the program will use the STRDOT optimizer and not other optimizer. If SRMET = 1, GENSIS will use the STRDOT optimizer first and then switch to DOT or BIGDOT.

9 Enhanced Data

9.1 Solution Control

KAA	Now allows to output files with large loadcase ID (up to 99999999).
MAA	Now allows to output files with large loadcase ID (up to 99999999).
KAASENS	Now allows to output files with large loadcase ID (up to 99999999).
MAASENS	Now allows to output files with large loadcase ID (up to 99999999).

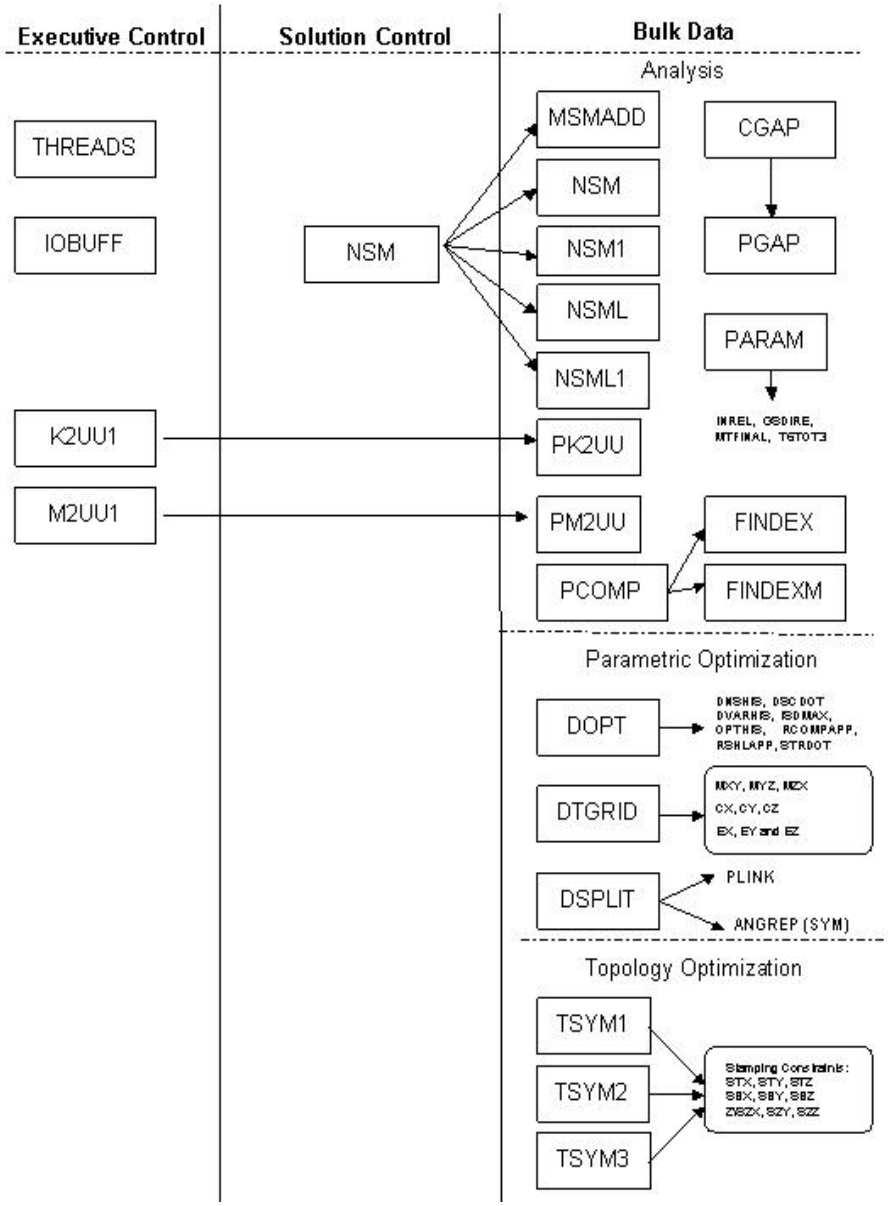
9.2 Bulk Data

DOPT	Now accepts the following new parameters: DNSHIS, DSCDOT, DVARHIS, ISDMAX, OPTHIS, RSHELPAPP, RCOMPAPP and STRDOT.
DSPLIT	Now accepts following data type: PLINK. With this new option, topometry optimization can now reference multiple properties, which in turn, allows global fabrication constraints. The SYM data type in DSPLIT now has a new option, ANGREP. This options makes angles corresponding to symmetric elements either mirror (new option; and now the default) or repeat (previous method). DSPLIT can now be used to design the new PK2UU and PM2UU data entries.
DTGRID	Now accepts following data type: SYM. With the SYM option, topometry optimization can now accept mirror, cyclic/radial and extrusion fabrication constraints
DVPROP1	Now can be used to design the PK2UU and PM2UU entries.
DVPROP2	Now can be used to design the PK2UU and PM2UU entries.
PCOMP	Now can use user-supplied failure indices specified in new entries FINDEX or FINDEXN.
PARAM	Now accepts the following new parameters: INREL and T6TOT3.
PROD, PBAR, PBARL, PBEAM, PSHEAR, PSHELL and PCOMP	Nonstructural mass can be added to PROD, PBAR, PBARL, PBEAM, PSHEAR, PSHELL and/or PCOMP using the new executive control command NSM and one or more of the following new bulk data entries: NSM, NSM1, NSML, NSML1 and NSMADD.
TSYM1	Now accept new fabrication constraints for sheet forming. The new fabrication constraints can be combined with the existing mirror or cyclic symmetries. The new fabrications constrains are STX, STY, STZ, SBX, SBY, SBZ, S2X, S2Y and S2Z.
TSYM2	Now accept new fabrication constraints for sheet forming. The new fabrication constraints can be combined with the existing mirror or cyclic symmetries. The new fabrications constrains are STX, STY, STZ, SBX, SBY, SBZ, S2X, S2Y and S2Z.

TSYM3	Now accept new fabrication constraints for sheet forming. The new fabrication constraints can be combined with the existing mirror or cyclic symmetries. The new fabrications constrains are STX, STY, STZ, SBX, SBY, SBZ, S2X, S2Y and S2Z.

10 New and Enhanced Data Relationships

The following figure shows the relationships of the new Genesis data enties.



11 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. Six new examples were added
GENESIS: Quick Reference Manual	quickref.pdf	Updated to reflect all changes and new data entries
GENESIS: New Features and Enhancements	newfeat.pdf	This document

12 New Example Problems

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

Name	Problem	Special Features
D073.dat	Topography Optimization of Multiple Regions and with Multiple Sets of Extrusion, Cyclic, Axisymmetric and Mirror Symmetry Constraints	Use of EX extrusion symmetry option, CZ cyclic symmetry option and MZX, MYZ, MXY mirror symmetric options in DTGRID
D074.dat	Three Rod Truss - Discrete Optimization Using DSCDOT	Use of the DSCDOT optimizer to obtain a discrete variable solution.
T018.dat	Solid Block Subject to Torsional Loads with Stamping Constraints - Use of Two layers With no Punch Holes	Use of S2Z stamping manufacturing constraint.
T019.dat	Solid Block Subject to Torsional Loads with Stamping Constraints - Use of Two layers With Punch Holes	Use of S2Z stamping manufacturing constraint.
T020.dat	Solid Block Subject to Torsional Loads With Stamping Fabrication Constraints. Use of One Layer With no Punch Holes - Layer Stamped from Bottom	Use of SBZ stamping manufacturing constraint.
T021.dat	Solid Block Subject to Torsional Loads With Stamping Fabrication Constraints. Use of One Layer With no Punch Holes - Layer Stamped from Top	Use of STZ stamping manufacturing constraint.

13 Changes in Version 10.0 with Respect to Version 9.0

Genesis version 10.0 should run any input that was successfully running in version 9.0 with no changes.

Two result files will no be longer printed by default: *pname*.OPT and *pname*.DNS. The *pname*.OPT files is used to print the updated grid locations and property values changed by optimization. This file can be printed by setting the new DOPT parameter OPTHIS to 1. The *pname*.DNS file is used to print the densities corresponding to a topology optimization run. This file can be printed by setting the new DOPT parameter DNSHIS to 1.

Topometry optimization results might change as a topometry move limit parameter has been adjusted. The new parameters value causes Genesis to converge, in most problems, in fewer design cycles. Old answers can still be obtained by setting the DOPT parameter DFRACT to 0.5.