Operator `DYNA_VISCO`

1 Goal

This order allows **to calculate the real or complex clean modes,** like **the harmonic answer** (displacement, speed, acceleration) of one **structure comprising of the viscoelastic materials whose properties depend on the frequency** (what results in a matrix of rigidity dependent on the frequency).

The following actions are possible:

- obtaining the modes by iterative method; 3 types of modes to the choice: real modes, real beta-modes or complex modes, with taking into account of the frequency response of the mechanical properties of viscoelastic materials;
- if there is an excitation, calculation of the harmonic answer of the structure; is calculated by projection on the modal basis established at the preceding stage, then restitution on the physical basis.

For more theoretical details, to refer to the reference document [R5.05.10].

The order can produce a concept of the type `mode_meca`, `mode_meca_c`, `dyna_harmo`.

Notice *:*

> *The order currently does not allow the calculation of the double modes;*
> *The structural analysis with modes of rigid body can not converge.*

2 Syntax

```
visco [*] = DYNA_VISCO (
```

 # Assignment of the model and the grid

```
♦ MODEL = model,                          [modele_sdaster]
```

 # Assignment of the characteristics of the elements and the limiting conditions

```
◊ CARA_ELEM = caraelem,                   [cara_elem]
```

 # Assignment of materials

elastic materials classical (constant properties)

```
◊ MATER_ELAS = _F (
                ♦ / MATER = chechmate          [mater_sdaster]
                  /♦ E = E                     [R]
                   ♦ AMOR_HYST = amorhyst      [R]
                   ♦ RHO = rho                 [R]
                   ♦ NAKED = naked             [R]
                ♦  GROUP_MA = gma              [l_gr_maille]
                )
```

materials viscoelastic (properties dependent on the frequency)

```
♦ MATER_ELAS_FO= _F (
                ♦ E = l_e                      [fonction_sdaster]
                ♦ AMOR_HYST = l_amor           [fonction_sdaster]
                ♦ RHO = rho                    [R]
                ♦ NAKED = naked                [R]
                ♦ GROUP_MA = gma               [grma]
                )
```

 # Choice of calculation to be carried out

```
◊ TYPE_RESU =   / 'HARM'                       [DEFECT]
                / 'MODE'

◊ TYPE_MODE =   / 'REAL'                       [DEFECT]
                / 'BETA'
                / 'COMPLEX'  (only if TYPE_RESU=' MODE')
```

C hoix of the frequencies of calculation:

```
♦/FREQ = l_f                                   [l_R]
 / LIST_FREQ = lfreq                           [listr8]
```

Rq: if `TYPE_RESU=' MODE'` , these keyword inform the frequential band of research of the clean modes and must thus comprise 2 values exactly

Rq: if `TYPE_RESU=' HARM'` , these keyword inform the discrete frequencies of calculation of the harmonic answer; the maximum value of the list, multiplied by `COEF_FREQ_MAX` , is the upper limit of research of the clean modes.

 # Parameter setting of convergence on the clean modes

```
◊ RESI_RELA = 1.E-3                            [DEFECT]
            / eps                              [R]
```

 # If *TYPE_RESU=' HARM'* :

```
  ◊ COEF_FREQ_MAX = cfmax                      [R]
```

 # Assignment of the loading

```
♦   EXCIT = _F (
                ♦ LOAD = load                         [l_char_meca]
               )
```

 # Choice of (of) the field (S) of result to save

```
◊   NOM_CHAM =/'DEPL'                                   [DEFECT]
               / 'QUICKLY'
               / 'ACCE'
```

 # possible Storage of the calculated clean modes

```
◊   MODE_MECA = CO ("modes")                            [TXM]
```

 # Posting of the relative information to calculation

```
◊   INFORMATION =    /  1                                      [DEFECT]
                /  2
);
```

 # Standard of concept result

If `TYPE_RESU = 'HARM'` then [*] = `dyna_harmo`
if `MODE_MECA` present, the concept `CO` is of type `mode_meca`.

If `TYPE_RESU = 'MODE'` then [*] = `mode_meca` if `TYPE_MODE = 'REAL'` or `'BETA'`
`mode_meca_c` if `TYPE_MODE = 'COMPLEX'`.

3 Operands

3.1 Operands MODEL/CARA_ELEM

```
♦   MODEL = model,
◊   CARA_ELEM = caraelem,
```

These keywords make it possible to inform:

- the name of the model (`model`) whose elements are the object of mechanical calculation.
- the name of the characteristics of the structural elements (plates, beams, discrete,…) if they are used in the model.

3.2 Keyword factor MATER_ELAS

```
◊   MATER_ELAS = _F (
                    ♦  /    MATER = chechmate
                       / ♦ E = E
                         ♦ AMOR_HYST = amorhyst
                         ♦ RHO = rho
                         ♦ NAKED = naked
                    ♦       GROUP_MA = gma
                    )
```

This keyword makes it possible to affect an elastic material **without frequency response** with the elements belonging to `GROUP_MA`.
The material can be defined before the macro-order thanks to the operator `DEFI_MATERIAU` [U4.43.01]; in this case, this material is recalled with the keyword `MATER`. The material can also be defined here by its properties: Young modulus `E`, density `RHO`, Poisson's ratio `NAKED`, and damping hysteretic `AMOR_HYST`.

This keyword factor can be repeated as many times as there are elastic materials **without frequency response** in the structure.

3.3 Keyword factor MATER_ELAS_FO

```
♦   MATER_ELAS_FO=   _F (
                        ♦ E = l_e
                      ♦   AMOR_HYST = l_amor
                      ♦   RHO = rho
                      ♦   NAKED = naked
                      ♦   GROUP_MA = gma
                      )
```

This keyword makes it possible to affect a viscoelastic material **with frequency response** with the elements belonging to `GROUP_MA`.
The mechanical properties of viscoelastic material are of two types:

- those which depend on the frequency: the Young modulus `E` and the damping ratio `AMOR_HYST` ; they are indicated by functions indexed by the frequency, produced by `DEFI_FONCTION/NOM_PARA=' FREQ'` [U4.31.02]);
- those which are constant: density `RHO` and the Poisson's ratio `NAKED`.

This keyword factor can be repeated as many times as there are materials visocelastic with **frequency response** in the structure.

3.4 Keyword TYPE_RESU

```
◊  TYPE_RESU =   / 'HARM'                 [DEFECT]
                 / 'MODE'
```

This keyword makes it possible to define the type of calculation to be carried out:

- LE choice `'MODE'` allows to calculate the clean modes of the structure;
- calculation `'HARM'` , allows to obtain frequency response of the structure a given excitation; one can also recover the clean modes calculated thanks to the keyword `MODE_MECA` .

3.5 Keywords FREQ/LIST_FREQ

```
♦  / FREQ = l_f
   / LIST_FREQ =   lfreq
```

In the case of a modal calculation of the structure (`TYPE_RESU=' MODE'`), this keyword makes it possible to define the frequential band of research of the modes. The list must then contain 2 values exactly (strictly increasing).

In the case of a harmonic calculation of the structure (`TYPE_RESU=' HARM'`), this keyword makes it possible to define the discrete frequencies for which the answer of the structure is calculated. The list must then contain at least 2 strictly increasing values.

3.6 Keyword TYPE_MODE / RESI_RELA

```
◊  TYPE_MODE =  / 'REAL'                  [DEFECT]
                / 'BETA'
                / 'COMPLEX'
```

Several choices of calculation of the clean modes are possible: real modes, beta-modes (which are real modes improved giving a better precision of the results, cf [R5.05.09]), like complex modes.
The calculation of the complex modes makes it possible to obtain modal depreciation. On the other hand this kind of mode cannot be used to carry out a harmonic calculation (`TYPE_RESU=' HARM'`).

Note:

If one calculates complex modes, one can recover modal depreciation in a list python with this function: `liste_python=modes.LISTE_PARA () ['AMOR_REDUIT']` (that nécesite to use `PAR_LOT=' NON'` in the order `BEGINNING`).

```
◊  RESI_RELA =  / 1.E-3                   [DEFECT]
                / eps
```

The calculation of the clean modes with the iterative method has named convergence criteria `RESI_RELA`. A clean mode is retained in the modal base when the relative difference between the Eigen frequencies calculated between two successive iterations is lower than `RESI_RELA`.

3.7 Keyword factor EXCIT

```
♦  EXCIT =_F (
                ♦ LOAD = load
             )
```

This keyword allows the assignment of loads (boundary conditions, forces of excitation,…) who were before defined by the operator `AFFE_CHAR_MECA` [U4.44.01].

Note:

Currently, for the external excitations, only the excitations of the type `FORCE_NODALE` are compatible with the order `DYNA_VISCO`.
For harmonic calculation, the base of the clean modes is enriched, a transparent way for the user, by the static modes associated with the excited nodes.

3.8 Keyword NOM_CHAM (if TYPE_RESU=' HARM')

```
◊   NOM_CHAM =    / 'DEPL'                 [DEFECT]
                  / 'QUICKLY'
                  / 'ACCE'
```

This keyword makes it possible to define which fields will be saved in the concept result (displacement, speed or acceleration). It is possible to save several fields by giving a list, for example `NOM_CHAM= ('DEPL', 'ACCE')`.

3.9 Keyword MODE_MECA (if TYPE_RESU=' HARM')

```
◊   MODE_MECA = CO ('modes')
```

If this keyword is present, two concepts will be produced by the macro-order:

- the concept `modes` of type `mode_meca`
- the concept `visco` of type `dyna_harmo`

The concept `modes` can for example be classically printed with the order `IMPR_RESU` [U4.91.01].

3.10 Keyword COEF_FREQ_MAX (if TYPE_RESU=' HARM')

```
◊   COEF_FREQ_MAX = cfmax                    [R]
```

During a harmonic calculation, the multiplying coefficient `COEF_FREQ_MAX` allows to obtain values of more precise frequencys response, while multiplying by `COEF_FREQ_MAX` the value of the maximum frequency of calculation of the modal base of projection.
The minimal value of this parameter is 1.5.

3.11 Keyword INFORMATION

```
◊   INFORMATION =    / 1                     [DEFECT]
                 / 2
```

Indicate the level of impression in the file `MESSAGE`.

4 Examples

4.1 Definition of the frequency response of the properties of viscoelastic materials

```
# frequencies for which the parameters of materials are given
list_f=DEFI_LISTE_REEL (VALE= (1,10,50,100,500,1000,1500,),);

# values (of the real part) of the Young modulus at the frequencies of list_f
list_E=DEFI_LISTE_REEL (VALE= (23.2E6,58.E6,145.E6,203.E6,348.E6,435.E6,464.E6,),);

# values of the factor of loss at the frequencies of list_f
list_eta=DEFI_LISTE_REEL (VALE= (1.1, 0.85, 0.7, 0.6, 0.4, 0.35, 0.34,),);

fonc_E=DEFI_FONCTION (NOM_PARA=' FREQ',
                     VALE_PARA=liste_f,
                     VALE_FONC=liste_E,
                     INTERPOL= ('FLAX', 'FLAX',),
                     PROL_DROITE=' LINEAIRE',
                     PROL_GAUCHE=' CONSTANT',);

fonc_eta=DEFI_FONCTION (NOM_PARA=' FREQ',
                       VALE_PARA=liste_f,
                       VALE_FONC=liste_eta,
                       INTERPOL= ('FLAX', 'FLAX',),
                       PROL_DROITE=' LINEAIRE',
                       PROL_GAUCHE=' CONSTANT',);
```

4.2 Calculation of the complex clean modes

```
modes=DYNA_VISCO (MODELE=modele,
                 CARA_ELEM=cara_ele,
                 # materials with constant properties:
                 MATER_ELAS=_F (E=2.1e11,
                               NU=0.3,
                               RHO=7800.,
                               AMOR_HYST=0.002,
                                GROUP_MA=' SUPPORT'),
```

```
                  # materials with properties dependent on the frequency:
                  MATER_ELAS_FO =_F (E=fonc_E,
                                     AMOR_HYST=fonc_eta,
                                     RHO=1200.,
                                     NU=0.45,
                                     GROUP_MA=' VISCO'),
                  TYPE_RESU=' MODE',
                   TYPE_MODE=' BETA',
                  # bandages frequential of research
                  FREQ= (1. , 1500.),
                  EXCIT=_F (CHARGE=condlim),
                  );
```

4.3 Calculation of the harmonic answer

```
# DEFINITION OF THE LOADING
excit=AFFE_CHAR_MECA (MODELE=modele,
                      FORCE_NODALE=_F (GROUP_NO=' A',
                                       FZ=1.,),);

# DEFINITION OF THE FREQUENCIES OF CALCULATION OF THE ANSWER
listfr=DEFI_LISTE_REEL (DEBUT=1.,
                       INTERVALLE= (_F (JUSQU_A=500.,
                                       PAS=1.,),),);

# ANSWER HARMONIC
visco=DYNA_VISCO (MODELE=modele,
                  CARA_ELEM=cara_ele,
                  EXCIT=_F (CHARGE= (condlim, excit),),
                  MATER_ELAS= (_F (E=2.1E11,
                               NU=0.3,
                               RHO=7800.,
                               AMOR_HYST=0.002,
                               GROUP_MA=' DESSOUS'),
                            _F (E=7.0E10,
                               NU=0.3,
                               RHO=2700.,
                               AMOR_HYST=0.001,
                               GROUP_MA=' DESSUS'),),
```

```
MATER_ELAS_FO= (_F (E=fonc_E,
                    AMOR_HYST=fonc_eta,
                    RHO=1200.,
                    NU=0.45,
                    GROUP_MA=' VOLUME',),),
TYPE_RESU=' HARM',
TYPE_MODE=' REEL',
LIST_FREQ=listfr,
# fields with saved
NOM_CHAM= ('DEPL', 'QUICKLY'),
# saves clean modes of the structure:
MODE_MECA=CO ('modes'),
);
```