
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 = amorphyst              [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')
```

Choice 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 viscoelastic 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 nécessite 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'),  
);
```