Postprocessing of modal computations with Summarized

shock:

This document presents the principle of postprocessing of transient computations by modal recombination with non-linearities of shock available in operator POST_DYNA_MODA_T.

Two options of postprocessing can be employed, the first usable one for problems of vibration-wear determines mean values and RMS of displacements, shock forces and power of wear dissipated on the level of the supports with clearances, second is applicable for the fine analysis of the impacts occurring during transitory requests, the instantaneous maximum force, the period of the time of shock, the impulse exchanged, the velocity before impact are given for each shock.

Contents

1 Introduction

Of the numerical developments were carried out into *Code_Aster* to allow the structure transient computation presenting of vibrations with shock in certain points. In certain cases, frictional forces can also appear and lead to a phenomenon of localised wear.

That it is about damage by pure impact or impact-friction, the engineer wishes to reach the quantities associated with this damage, which requires a specific postprocessing behind nonlinear transient computation.

This information of postprocessing is also invaluable when one wishes to validate the modulus of nonlinear computation by comparing his results with what can be measured on a specific test bench. Test routines (MASSIF and MULTICHOC) were implemented with this aim and were the first users of these functionalities of postprocessing.

The purpose of this note consists in specifying the quantities to be analyzed in vibrations with shock and their specificity. It is then a question of determining the suitable statistical processing to apply to these signals to release from the instantaneous quantities or the most characteristic averages.

Initially one will see the processing applied in the case of a problem with shock and friction (option "`USURE`" of the command `POST_DYNA_MODA_T`).

The following chapter will be devoted to the processing applied in the case of a phenomenon of pure vibration-impact, where the quantities of each impact are analyzed more finely (option "`IMPACT`" of the command `POST_DYNA_MODA_T`).

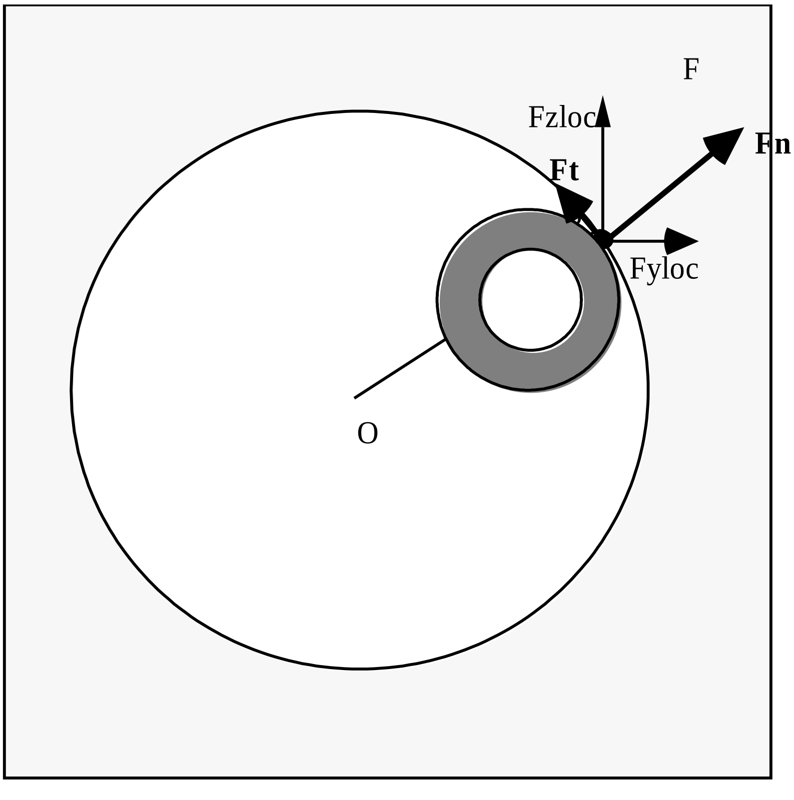
2 Quantities considered in vibrations with shocks

the primary quantities considered in vibrations with shock are identical that it is experimental measurements or numerical computation, they relate to the shock forces and the displacements on the level of the points of shock. The experimental results however present an additional difficulty of analysis due to the errors or skews introduced by the systems of measurement.

We will examine the two quantities quoted successively previously.

2.1 Shock forces

the first concern concerning structures vibrating with shocks is better to know the forces received by structure during the shocks on its bearings with clearances or between structures. These data are calculated in a temporal way by the algorithm of `DYNA_TRAN_MODAL`, they are then filed with a step defined in this same operator. The data of shock having very important frequential contents one will take care to have a sufficient archivage (not to exceed `PAS_ARCH` : 10). These forces expressed in a local coordinate system with the obstacle $(Yloc, Zloc)$ are traditionally broken up into a normal to the obstacle part (Fn on the figure below) and a tangential part (Ft) so of friction is taken into account between structures. The conditions of shock make that the normal force of shock has a constant sign taken conventionally positive in *Code_Aster*.



2.2 Displacements of shock

displacements of structure on the level of its bearings with clearance are another calculated important information. Its analysis poses however less problems because the spectral contents are less rich. In the case of circular or described obstacles in a polar way, a polar description of displacement can be interesting.

2.3 Secondary quantities

2.3.1 Time of shock

the time of contact between structure and the supports with clearances is an indirect quantity characteristic of the motion of vibration with shock. It can be deduced from various ways, on a criterion of displacement, positive reaction force. A notion of time of total shock, broken up into elementary shock (or rebound) will be introduced in [§3.4].

2.3.2 Calculated quantities

Of other secondary quantities can be important in the analysis of the conditions of shock, it acts of **the impulse** at the time of the impact (integral of the exchanged force), **the power of wear**, **the maximum force** during an impact,… These quantities are specific to each postprocessing and they will be specified in the two chapters which follow for postprocessing option "`USURE`" and "`IMPACT`".

3 Modal transitory postprocessing – option "USURE"

the characterization of transitional measures is the goal of the processing of the signal. He teaches us that a signal is entirely determined by the data of all its statistical moments. In the practice it is out of question calculating every statistical moment, one is limited in postprocessing to the quantities calculated classically in processing of the signal (simple average, standard deviation and value RMS). They are characteristic of the signals which one wishes to analyze and compare. Similar signals must necessarily have these first close statistical moments (the reciprocal one being false). The statistical quantities selected here are well appropriate to the analysis, the comparison or classification of signals of vibrations under random excitation with non-linearities of shock.

We will thus examine the realised quantities and their computation, by distinguishing the various quantities quoted in the preceding chapter:

- displacements,
- shock forces,
- determination of the contact and of the time of contact.

Other made up information could be calculated starting from the preceding ones in particular the power of wear.

3.1 Statistical processing per blocks

In order to analyze the stationarity of the signals and the statistical processing carried out on the signals, one carries out a cutting per blocks of the temporal signals. Thus the period of postprocessing defined between initial time (`INST_INIT`) and final moment (`INST_FIN`) is cut out in a number of temporal blocks (`NB_BLOC`) of identical period. The computation statistics: average, standard deviation,… are carried out for each block, a general value for the signal for all the blocks is also calculated.

In the case of a computation of response of a structure to a random loading, this technique of computation per blocks makes it possible to make sure that the transitional stage of computation is finished and that the announced value is quite steady over a time of observation associated with the period with computation.

3.2 Statistical processing applied to displacements of shock

Let us consider the temporal signal $Depl\_x(t)$, which one carries out an archivage with a certain frequency F_{acquis} on N points. The starting data is thus a vector $Depl\_x(i)$ with N components.

Average displacement is defined in this case by:

$$\overline{Depl\_x}=\frac{\sum_{1}^{N} Depl\_x(i)}{N}$$

This mean value characterizes the central value around which the signal of displacement evolves. For displacements, it will thus make it possible to determine if one observes a centered (displacements with average null), or offset configuration (average non-zero).

The variance of displacement is by definition:

$$var(Depl\_x)=\frac{\sum_{1}^{N}(Depl\_x(i)-\overline{Depl\_x})^2}{N}$$

The standard deviation of displacement is worth then:

$$\sigma(Depl\_x)=\sqrt{var(Depl\_x)}$$

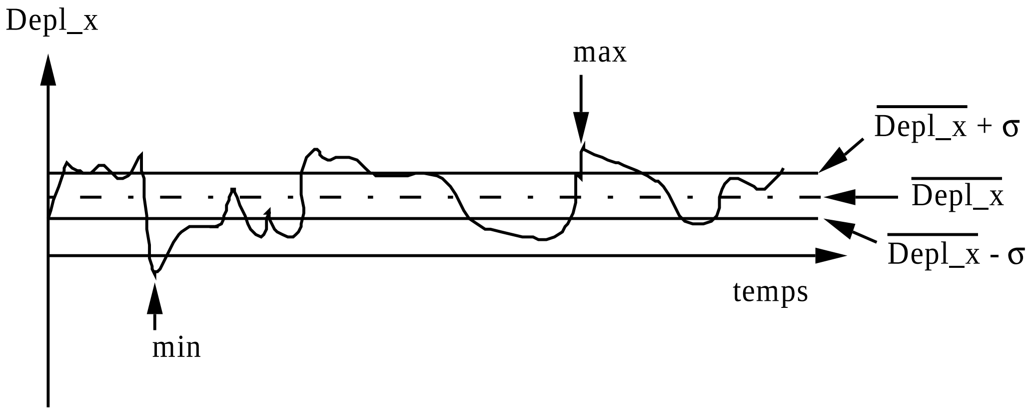
The standard deviation of a signal characterizes its dispersion around its mean value. A weak standard deviation will rather relate to a signal with weak variations of amplitude, a strong standard deviation of the stronger variations.

For a centered variable i.e. with average null, the standard deviation is equal to average RMS of the signal (Root Mean Public garden).

For an unspecified variable one defines **average RMS** of the signal by:

$$RMS(Depl\_x)=\sqrt{\frac{\sum_{1}^{N} Depl\_x(i)^2}{N}}$$

The minimum and maximum absolutes of the signal are also information interesting and very simple to obtain, which determines the extent of the signal.



Appear 3.2-a: Example of signal of displacement and visualization of the statistical quantities

a polar representation of all the signals $Depl\_x$ and $Depl\_y$ is also interesting to analyze an obstacle of circular or close geometry in the case of. Let us be appropriate to call R radial displacement and θ angular displacement, equivalents of $Depl\_x$ and $Depl\_y$ into polar.

By definition one a:

$$R(i)=\sqrt{Depl\_x(i)^2+Depl\_y(i)^2}$$
$$\theta(i)=Arctg\left(\frac{Depl\_y(i)}{Depl\_x(i)}\right)$$

This representation allows inter alia things to distinguish:

- orbital motions with permanent contact (average radial displacement about clearance and standard deviation of weak radial displacement),
- of motions of pure impact (standard deviation of important radial displacement, variation of weak angular displacement),
- other configurations: orbital motion with impacts…

Note::

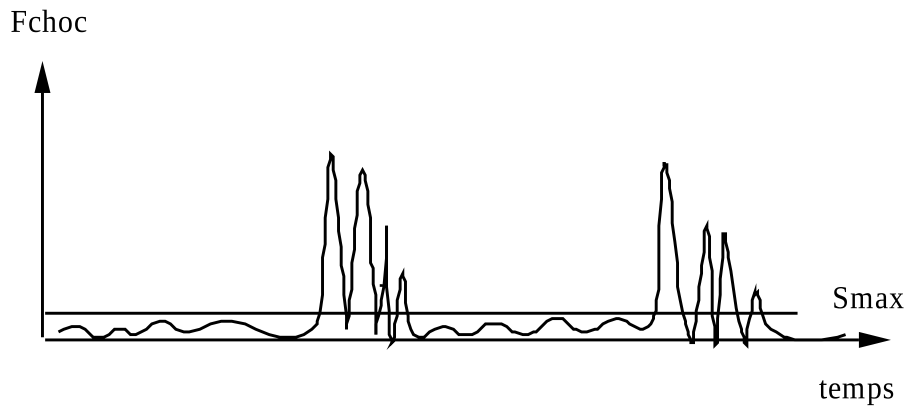
In the local coordinate system chosen for the obstacles of shock, the quantities called here $Depl\_x$ and $Depl\_y$ are in fact $DYloc$ and $DZloc$, the axis $Xloc$ having been chosen by convention perpendicular to the plane of the obstacle.

In short, the option of postprocessing **"USURE"** of operator POST_DYNA_MODA_T will determine for local displacements $DYloc, DYloc, DZloc$ like for their polar decomposition R and the θ statistical quantities per blocks with the principle stated above:

- mean value,
- value RMS,
- standard deviation,
- minimal value,
- maximum value.

3.3 Statistics for the shock forces

One supposes to lay out as for displacements of a discrete signal on N points: $Fx\_choc(i)$. The signal obtained should be made up of temporal beaches where the shock force is null (not contact) and others where the shock force is significant (effective contact), which is the numerical case during computations. In fact, for experimental signals, because of the dynamics of the system of measurement, a noise level can be observed except period of shock (cf [Figure 3.3-a]). It is thus necessary only to carry out the statistical processing when the signal leaves the sound level. That requires the introduction of a threshold of detection (**SEUIL_FORCE**) which, although superfluous in the numerical field, was reproduced in the postprocessing of *the Code_Aster*.



Appear 3.3-a: Example of experimental signal of shock force

Is the value $S\,max$, determining the maximum level of the noise considered, one then will calculate:

- **The number of times in shock** :

$$Nchoc=card\left\{i/|Fx\_choc(i)|>S\,max\right\}$$

- **The average of shock force** over **total time** :

$$\overline{Fx\_choc}=\frac{1}{N}\cdot\left(\sum_{i/|Fx\_choc(i)|>S\,max}^{N}|Fx\_choc(i)|\right)$$

- **The average of shock force** brought back at the time of **shock** is worth:

$$Fx\_choc=\overline{Fx\_choc}\cdot\frac{N}{Nchoc}$$

- **Average RMS of shock force** over **total time** is calculated in the following way:

$$RMS(Fx\_choc)=\left(\frac{1}{N}\sum_{i/|Fx\_choc(i)|>S\,max}^{N} Fx\_choc(i)^2\right)^{1/2}$$

- **Average RMS** brought back at the time of **shock** is worth:

$$RMS(Fx\_choc)=RMS(Fx\_choc)\cdot\frac{N}{Nchoc}$$

As for the signals of displacements, one can also be interested to **the maximum or minimum absolute** signal of force, thus determining his extent. For the normal force, the minimum is always equal to zero, whereas the tangential force is alternate.

In short, the option of postprocessing "`USURE`" of operator `POST_DYNA_MODA_T` will determine for the normal and tangential shock forces the statistical quantities per blocks with the principle stated above:

- mean value on the time of shock or total time,
- value RMS calculated over the time of shock or total time,
- maximum value of the signal.

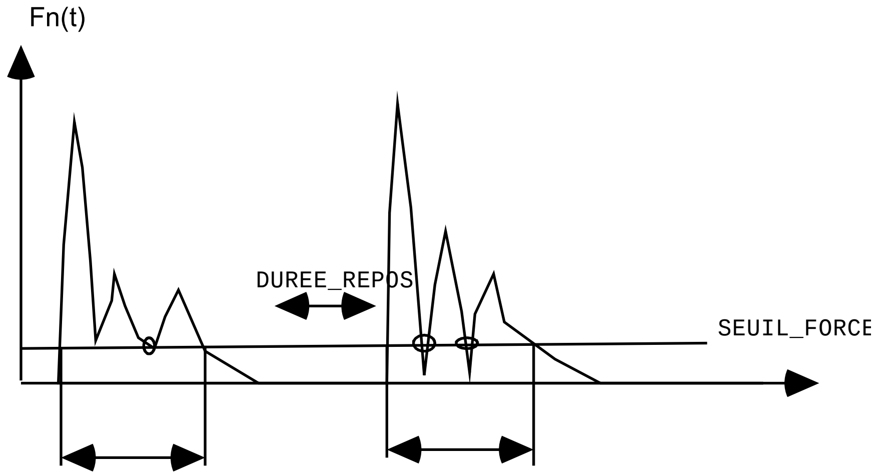
3.4 Statistics for times of shock

the percentage of time of shock is defined by:

$$\%Tchoc=Nchoc/N$$

If one looks at information which one has on an experimental system, the signal of shock force is adapted the most to determine in a precise way the occurrence of a contact. As one evoked with the top one tests the need to introduce a maximum level of noise, and to count the shock phases when the signal exceeds this threshold (`SEUIL_FORCE`).

On the figure below, one can distinguish a notion of **given elementary** shock like a successive transition with the top then with the lower part of the threshold, and a more general notion of **total shock**, gathering several elementary shocks separated by short moments from return under the threshold.



Appear 3.4-a

One thus introduces a time characteristic of rest Tr (**DUREE_REPOS**); end of an occurring time of total shock if the signal remains during a time at least higher than Tr at rest. This notion of time characteristic of rest Tr is well heard enough rooks and will have to be given by the user within sight of the transitory results. It is nevertheless essential because it only makes it possible to gather a train of constituting very brought closer impact makes only one phase of contact of it.

The notion of elementary time of shock being defined, the statistical processing over the time of shock will consist in determining following information:

- **many elementary shocks** : Nb_choc_elem
- **many total shocks** : Nb_choc_glob
- **many elementary shocks per total shock** : $\frac{Nb\_choc\_elem}{Nb\_choc\_glob}$
- **time of average elementary shock**:

$$\bar{T}_{choc\_elem} = \frac{Nchoc \cdot \Delta t}{Nb\_choc\_elem}$$

- **time of total shock average**

$$\bar{T}_{choc\_glob} = \frac{Nchoc \cdot \Delta t}{Nb\_choc\_glob}$$

- **time of maximum total shock** the greatest time of total shock noted on the analyzed block.

In short, the option of postprocessing **"USURE"** of operator POST_DYNA_MODA_T will determine for times of shock the statistical quantities per blocks with the principle stated above:

- mean value of the time of total shock, "
- maximum value of the time of total shock,
- mean value of the elementary time of shock,
- the number of total shocks a second,
- the average number of shocks elementary per total shock.

3.5 Power of wear

the quantity generally calculated in vibrations with shock and friction is the power of wear defined by ARCHARD [bib1], which during translates the average power developed by the frictional forces motion. These forces are the engine of wear by friction. The power of wear in the case of discrete signals is calculated as follows:

$$\overline{P_{usure}} = \frac{\sum_{i/|Fn|> S\,max}^{N} |Fn(i) \cdot Vt(i)|}{N}$$

This power can for example be correlated with a wear or removal of matter via a coefficient of wear K_T by a relation of the type: $V(T) = K_T * P_{usure} * T$ where $V(T)$ is the volume removed for the length of time T.

Other more sophisticated laws of attrition can be used in another operator of post - processing: POST_USURE describes in [R7.01.10].

3.6 Data format array POST_DYNA associated with option "USURE"

a structure of the type counts for L" option **USURE** of L" operator POST_DYNA_MODA_T gathers the results previously described.

This array contains the names of the under-arrays of results statistical associated with the various analyzed quantities: displacements, shock forces, counting of the shocks and power D" wear.

The variables D" access of this array are 10:

- **for the variables displacement** : DEPL_X, DEPL_Y, DEPL_Z, DEPL_RADIAL, DEPL_ANGULAIRE, which correspond respectively to displacements in X, Y and Z local and their cylindrical decomposition in the plane of L" obstacle.
- **for the variable shock forces** : FORCE_NORMALE, FORCE_TANG_1, FORCE_TANG_2, which correspond respectively to the normal forces, tangential with L" obstacle the first being in the plane of the obstacle, the second orthogonal to plane of the obstacle.
- **for the variables counting of shock** : STAT_CHOC.
- **for the variables power of wear** : PUIS_USURE.

Under arrays associated with the 10 quantities above, a certain number of variables of access for each connection of shock contain:

- **for the variables displacement** : LAYER, ECART_TYPE, RMS, MAXI, MINI, which correspond respectively to the values average, standard deviations, value RMS or effective, maximum and minimal value of variable displacement corresponding.
- **for the variable shock forces** : MOYEN_T_TOTAL, MOYEN_T_CHOC, RMS_T_TOTAL, RMS_T_CHOC, MAXI, which correspond respectively to the values average over total time, average over the time of shock, value RMS or effective average on time total, value RMS or effective over the time of shock, maximum value of the variable forces corresponding.
- **for the variables of counting of the shocks** : NB_CHOC_S, NB_REBON_CHOC, T_CHOC_MOYEN, T_CHOC_MAXI, T_CHOC_MINI, T_REBON_MOYEN, %_T_CHOC, which correspond respectively to the values amongst shocks a second, amongst rebounds by shock, of the time of average shock, time of maximum shock, time of minimal shock, time of average rebound and percentage of time of shock.
- **for the variable power of wear** : PUIS_USURE which corresponds to the power of wear calculated according to ARCHARD.

4 Modal transitory postprocessing – Usual practice option "IMPACT

4.1 " of postprocessing of computations of heart

the SEPTEN used, before development of postprocessing in *Code_Aster*, for its needs for checking of design, the code CLASH [bib2] developed by the BELGONUCLEAIRE. This software calculates the seismic response of a file of assemblies. This code provides a set of detailed information for each point of shock and each impact.

Each result consists of a table by point of shock whose example is in 16. This table comprises following information:

- the time of the peak of impact,
- the maximum force of impact reached,
- the exchanged impulse, defined as the integral of the shock force on time,
- the total period of the shock,
- the relative velocity before impact.

These elements are particularly interesting for the SEPTEN because in addition to very restricted contractual information, they make it possible to know the number and the composition of the impacts, as of the essential physical quantities which theirs are associated. The relative velocity before impact, the impulse are for example very invaluable information in the specification of experimental tests of dynamic buckling of the grids of assemblies.

4.2 Computations for the postprocessing of the impacts

One regards as for preceding postprocessing that the conditions of impact are given like previously by going beyond a force threshold $Smax$ and one in the same way distinguishes total shock and elementary shock by the notion of rest period.

The computation carries out a loop on all non-linearities of shock and an identical processing for each one.

Then for each identified total shock, one will determine the following quantities:

- Time of beginning of shock: $T_{début}$ tel que $F_{choc}(T_{début}) > S_{max}$
- Time of end of total shock:

$$T_{fin} \text{ tel que } F_{choc}(T_{fin}) \leq S_{max}, F_{choc}(T_{fin} - \Delta t) \geq S_{max}$$
$$\text{et } \forall t \in [T_{fin}, T_{fin} + T_{repos}] F_{choc}(t) \leq S_{max}$$
$$\text{où } \Delta t \text{ est le pas de temps d'intégration}$$

- Total period of the shock: $T_{choc} = T_{fin} - T_{début}$
- Maximum of force during the shock: $F_{max} = max_{T \in [T_{début}, T_{fin}]}(F_{choc}(t))$
- The time of maximum of shock force,
- the impulse exchanged during the shock: $I = \int_{t=T_{début}}^{T_{fin}} F_{choc}(t) \cdot dt$
- Relative normal velocity before impact: $V_{choc} = V(T_{début} - \Delta t)$
- The number of elementary impacts cumulated in the total shock:

$$N_{impacts\,élémentaires} = card\left\{ t \in [t_{début}, T_{fin}] / F_{choc}(t) > S_{max} \text{ et } F_{choc}(t + \delta t) \leq S_{max} \right\}$$

In order to synthesize information, one will moreover determine:

- the absolute maximum of shock force, on a connection of shock given, for the period of analysis,

  The maximum of shock force to be more precisely given will not be obtained like the max in time on all of the shocks for each node of shock (to avoid the skew of the accuracy of the archivage) but given in transient computation on all the computation step and will be filed in the result concept **`tran_gene`**. It is this information which will be used.

- the mean value of the extréma of shock force like their standard deviation.
- a histogram of the density of probability of the maximum forces of impacts.

  This histogram will be relatively summary and will give for N_C classes the density of probability of the maximum force of shock.

  The classes will be in the following way defined:

$$classe_{i=1..N_C}=\left\{F_{max}/\frac{i-1}{N_C}F_{max}^{absolu}\leq F_{max}\leq\frac{i}{N_C}F_{max}^{absolu}\right\}$$

4.3 Data format array POST_IMPACT associated with option "IMPACT"

4.3.1 Counts POST_IMPACT

a data structure of the type for the option counts **IMPACT** of operator POST_DYNA_MODA_T of *Code_Aster* is produced.

The structure of result will be a subscripted array by the names of connections of shock, type **POST_IMPACT,** container of the names of arrays which it contains.

The contents of each cell of this array are a name of array stored in CHARACTER*24. Three types of array are contained: an array known as IMPACT, an array known as GLOBAL and an array known as PROBA.

It thus has 3 parameters: **IMPACT**, **GLOBAL** and **PROBA**. The variable of access corresponds in the name of the connection of shock considered.

4.3.2 Count IMPACT

array IMPACT is of type **TABL_IMPACT** and has 6 parameters of access: **INST**, **F_MAX**, **T_CHOC**, **IMPULS**, **V_IMPACT**, **NB_IMPACT**.
The contents of each cell of this array are **a REAL*8**.

4.3.3 Count GLOBAL

array GLOBAL is of type **TABL_FMAX** and has 3 parameters of access:

- **F_MAX_ABS**, which give access the absolute maximum of shock force on all the noted shocks,
- **F_MAX_MOY**, which gives access the mean value of maximum of shock force noted,
- **F_MAX_ETYP**, which gives access the standard deviation of the extrema of shock forces.

The contents of each cell of this array are **a REAL*8**.

4.3.4 Count **PROBA**

array `PROBA` is of type **TABL_HISTO** and has 3 parameters of access:

- **debut**, which gives access the value of minimal force of the class i ,
- **FIN**, which gives access the value of maximum force of the class i ,
- **PROBA**, which gives access the density of probability of the variable forces maximum for the class i .

The contents of each cell of this array are `a REAL*8`.

5 Conclusion

One presented in this document the methods of postprocessing applicable to the transients with shock calculated by modal synthesis on structures with clearance. According to the concerns, one can during carry out a postprocessing directed towards a diagnosis of the wear undergone by the components the shocks, a set of statistical quantities important are then determined. If the concern rather relates to the impacts and their level, another option allows a detailed analysis of each impact.

These two features make it possible to synthesize the transitory results got by integration temporal, to classify by level of severity of different computational simulations or to compare at ends of validation of the calculated and measured quantities.

6 Bibliography

1) ARCHARD J.F and HIRST W.: The wear of metals under unlubrificated conditions - Proc. Roy. Plowshare (1956).

2) J.P. FABRY, A. DECAUWERS: Code CLASH - Study Seismic of a line of assemblies REFERENCE MARK.

7 Description of the versions of the document

Version Aster	Author (S) Organization (S)	Description of the modifications
3	*G.JACQUART -EDF-R&D/AMV*	initial Text

Annexe 1 : Example of array obtained with option "IMPACT"

```
#-----------------------------------------------------------------------------------
#
#ASTER 10.03.00 CONCEPT dynachoc CALCULE LE 3/11/2011 A 17:47: 02 OF TYPE
#TABLE_SDASTER

 INTITULE     NOEUD       CALCUL        CHOC             TIME             F_MAX
 CLOAS_2G     N1150       IMPACT                  1       4.99500E-02       3.89961E+03
 CLOAS_2G     N1150       IMPACT                  2       5.50500E-02       3.59805E+03
 CLOAS_2G     N1150       IMPACT                  3       1.19750E-01       6.22654E+03
 CLOAS_2G     N1150       IMPACT                  4       1.20900E-01       2.72275E+03
 CLOAS_2G     N1150       IMPACT                  5       1.29750E-01       3.99908E+03
 CLOAS_2G     N1150       IMPACT                  6       1.30900E-01       1.29756E+03
 CLOAS_2G     N1150       IMPACT                  7       1.39500E-01       4.01287E+03
 CLOAS_2G     N1150       IMPACT                  8       2.33900E-01       3.40404E+03
 CLOAS_2G     N1150       IMPACT                  9       2.58100E-01       5.35569E+03
 CLOAS_2G     N1150       IMPACT                 10       3.64750E-01       5.97765E+03
 CLOAS_2G     N1150       IMPACT                 11       4.36300E-01       1.43427E+03


 INTITULE     NOEUD       IMPULSE         T_CHOC          V_IMPACT        NB_IMPACT
 CLOAS_2G     N1150        1.10221E+00     4.50000E-04    -4.91957E-01             1
 CLOAS_2G     N1150        1.99430E+01     8.00000E-03    -9.78335E-02             1
 CLOAS_2G     N1150        1.86814E+00     5.00000E-04    -7.36592E-01             1
 CLOAS_2G     N1150        8.43181E+00     4.30000E-03    -9.18914E-02             1
 CLOAS_2G     N1150        1.35933E+00     5.50000E-04    -4.88723E-01             1
 CLOAS_2G     N1150        1.00883E+00     1.70000E-03    -4.32639E-02             1
 CLOAS_2G     N1150        3.22593E+00     2.60000E-03    -4.30045E-01             1
 CLOAS_2G     N1150        1.48165E+01     6.65000E-03    -4.09494E-01             1
 CLOAS_2G     N1150        2.26770E+01     7.75000E-03    -5.64720E-01             1
 CLOAS_2G     N1150        2.27097E+01     6.80000E-03    -5.53400E-01             1
 CLOAS_2G     N1150        4.80676E+00     7.80000E-03    -1.68167E-01             1


 INTITULE     NOEUD       CALCUL          F_MAX_ABS       F_MAX_MOY       F_MAX_ETYPE
 CLOAS_2G     N1150       GLOBAL           6.22654E+03     3.81165E+03     1.54804E+03


 INTITULE     NOEUD       CALCUL   CLASSE     debuts         FIN           PROBA
 CLOAS_2G     N1150       PROBA            1   1.29756E+03   1.79046E+03   1.81818E-01
 CLOAS_2G     N1150       PROBA            2   1.79046E+03   2.28336E+03   0.00000E+00
 CLOAS_2G     N1150       PROBA            3   2.28336E+03   2.77626E+03   9.09091E-02
 CLOAS_2G     N1150       PROBA            4   2.77626E+03   3.26915E+03   0.00000E+00
 CLOAS_2G     N1150       PROBA            5   3.26915E+03   3.76205E+03   1.81818E-01
 CLOAS_2G     N1150       PROBA            6   3.76205E+03   4.25495E+03   2.72727E-01
 CLOAS_2G     N1150       PROBA            7   4.25495E+03   4.74785E+03   0.00000E+00
 CLOAS_2G     N1150       PROBA            8   4.74785E+03   5.24074E+03   0.00000E+00
 CLOAS_2G     N1150       PROBA            9   5.24074E+03   5.73364E+03   9.09091E-02
 CLOAS_2G     N1150       PROBA           10   5.73364E+03   6.22654E+03   1.81818E-01
```