HANS meets the GNS software Working with HBMs in Generator4 and Animator4

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1 Abstract

New trends and developments in the automotive market have caused changes in the way we evaluate and analyze our vehicles.
For example, the introduction into the market of vehicles with autonomous driving capabilities has led to an explosion in the number and variability of possible passenger positions within the vehicle cabin. Positions for which conventional dummy models have limitations due to the unidirectionality of their components and sensors.

Also, the number of scenarios to be evaluated has become enormous. This limits real crash tests to a validation position, shifting the burden of development to virtual tests that are much faster and cheaper to perform. Also opening the door to future certifications based on the results of simulations, not requiring hardware to support the concrete results.

Human models are the answer to these new needs. Advances in modeling and simulation techniques have made it possible to faithfully represent the most complex hardware involved in the various road safety situations: the human body.

Under these circumstances HANS was born, DYNAmore's human model characterized by its detail and excellent performance. Like other human models on the market, it is a complex model that requires powerful software that allows it to be easily managed. GNS-mbH offers its well-known products in response to this new need: The Generator4 pre-processor and the Animator4 post-processor.

Thanks to Generator4, complex human models such as HANS can be comfortably positioned through a simple GUI that is as flexible as the model itself. An industry that requires high realism in passenger models also expects an elevated level of accuracy in capturing the effects of changing model position and interaction with the environment, seat deformations and realistic positioning of anchoring systems. It will be shown how Generator4 allows to design and simulate the process of positioning, seating and buckling of HMBs in a simple and automatable way, using the high simulation capacity and accuracy of LS-Dyna itself as solver.

The evaluation of these models also represents a challenge due to the large amount of data that can be obtained, which can overwhelm the engineer. A powerful evaluation tool that allows a highly automated process is crucial. Animator4 provides the possibility to obtain such results in a comfortable and automated way.

2 Introduction to human body models. Meeting Hans

Human body models (commonly abbreviated as HBMs) are faithful representations of an average human being that have been widely introduced in recent times in the areas of numerical simulation dedicated to design processes in the automotive sector.

This introduction is necessary and convenient due to market trends.

The irruption of models with autonomous driving has meant a real revolution. Not only in the way we drive, but also in the way we must assess vehicle safety. Autonomous driving opens the door to countless new ways of travelling and new cabin layouts. The possibilities are virtually endless. However, safety standards must not be compromised, complicating the development process.

On the one hand, this will be reflected in new occupant positions to be assessed regarding their safety. This is where conventional dummies present great difficulties. They cannot adapt to all required

positions, and it is not possible to evaluate their responses in any direction due to hardware limitations. HBMs do not present this difficulty, giving complete flexibility in using the same model for different configurations and test cases.

On the other hand, in a globalized world it is becoming increasingly important to implement design methodologies that are both time and cost efficient. The possible configurations to be evaluated are multiplying. They are virtually infinite. Therefore, the burden of decision making will increasingly fall on the virtual world: Numerical simulation will become more important than real tests.

This fact reduces the major handicap that HBMs could present: The lack of hardware with which to carry out real tests and validation of calculations.

In recent times multiple HBMs have been introduced in the market. One of these models is Hans.

Fig.1: Hans model overview [1]

Hans is a high technical quality model that has been developed by DYNAmore (an Ansys company)©. As indicated in their portfolio, the model has been defined with state-of-the-art LS-Dyna definitions and various features and highlights, such as [1]:

1. Level of detail: Realistic modeling of the musculoskeletal system for detailed analysis of the skeleton and musculature at the geometric and material level.
2. Robustness: Includes robustness considerations during meshing and material card generation.
3. Efficiency: Moderate element count and moderate use of “expensive” solver functions.
4. Ease of use: Supporting the entire workflow with positioning concepts, pre- and post-processing tools and user assistance.

This model has been used to carry out benchmark tests from the GNS mbH software in order to optimize the user experience when working with HBMs. Proposed software solutions and improvements being currently carried out with this regard will be exposed.

3 Positioning human body models

3.1 Related difficulties

The use of human body models brings great improvements in terms of flexibility and fidelity. However, it is also accompanied by difficulties in terms of handling due to the complexity of such realistic models. Just considering the size of the models (presenting in many cases more than 2 million elements and

with vast articulation structures required to reflect the human movements) the preprocessing of these models can be tedious if not performed with the appropriate tools.

Firstly, the models must be articulated within the pre-processor to achieve the study position to be evaluated. Being such realistic models, this usually involves determining the angle and position of many joints. The human body's limitations in angles and postures must also be considered.

However, the model cannot be treated as a simple solid-rigid during the process. The materials used reflect the organs and tissues of a real human. Deformations and stresses must be considered, while initial penetrations of any kind must be avoided. Therefore, a simulation is necessary beforehand for a correct positioning of the model to avoid initial penetrations of any kind.

3.2 Generator4 solution for HBM positioning with ease

3.2.1 Model articulation

Generator4 is a preprocessor with which the engineer can easily define his finite element models, both for LS-Dyna© and for the other solvers it offers.
Within the preprocessor, the user has at his disposal a variety of tools dedicated to the automotive field. One of these tools is the dialog dedicated to the positioning of both traditional dummies and the humanoid models. Thanks to being a single dialog, the user is not forced to learn any new processes.
As a first step, the user can move, rotate, and articulate the humanoid to the desired position. Different options for articulating the HBM are offered depending on the user's needs and preferences:

1. Rotating the different joints, thus defining the exact angles needed for each articulation.
2. Defining the location in space of any node in the model, for which the user may have some coordinate requirements.
3. Setting the position of any articulation by setting the exact coordinates.

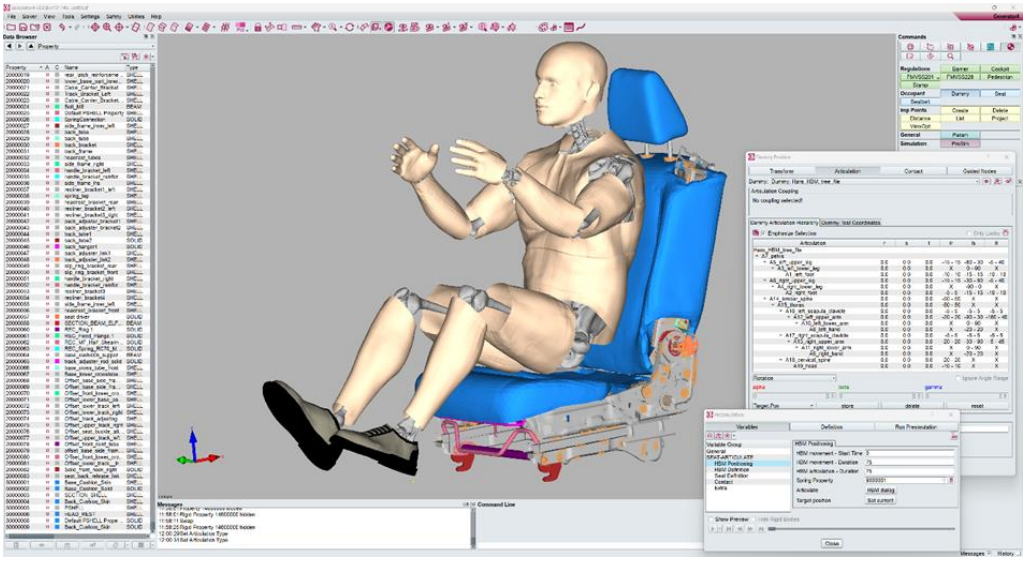

Fig.2: Generator4 Layout. Dedicated dialogs for HBMs positioning

These options are methodical and simple to follow, but due to the considerable number of moving parts in the human body models, this work can be costly. In these cases, a more dynamic solution is necessary.

To facilitate the complex process of HBM articulation, it is possible to position these models by means of drag & drop. Thanks to Generator4, the user can modify the position of the HBM by grabbing each member of the model and placing it in the desired position interactively and in real time. This saves time for the engineer, who will now be facing a simple and intuitive job.

Along with the definition of each parameter or angle and the drag & drop option, a third option is available: The test coordinates option.

Thanks to a powerful algorithm for processing and evaluating the kinematic structure of the model, it is possible to position all limbs, spine and even the general position of the HBM (pelvis coordinates and rotation angles) with a single click.

To do this, the engineer provides a list of targets for his choice's markers (both in number and location). This option is of interest when real test measurements are available. In the case of HBMs, this can come from biometric measurements of study subjects, X-rays, or even crash test markers on real cadaver tests.

3.2.2 Pre Simulation set up

Once the HBM has been articulated as a rigid body in Generator4, the model will present penetrations. A pre-simulation is necessary to obtain a realistic position of the HBM. But defining these simulations where the HBM moves from its initial position to the required position can be complex.

However, Generator4 simplifies the generation of these input decks, by offering a dedicated module where the user only must import pre-defined generic processes and adapt them to his concrete model by adapting a few variables.

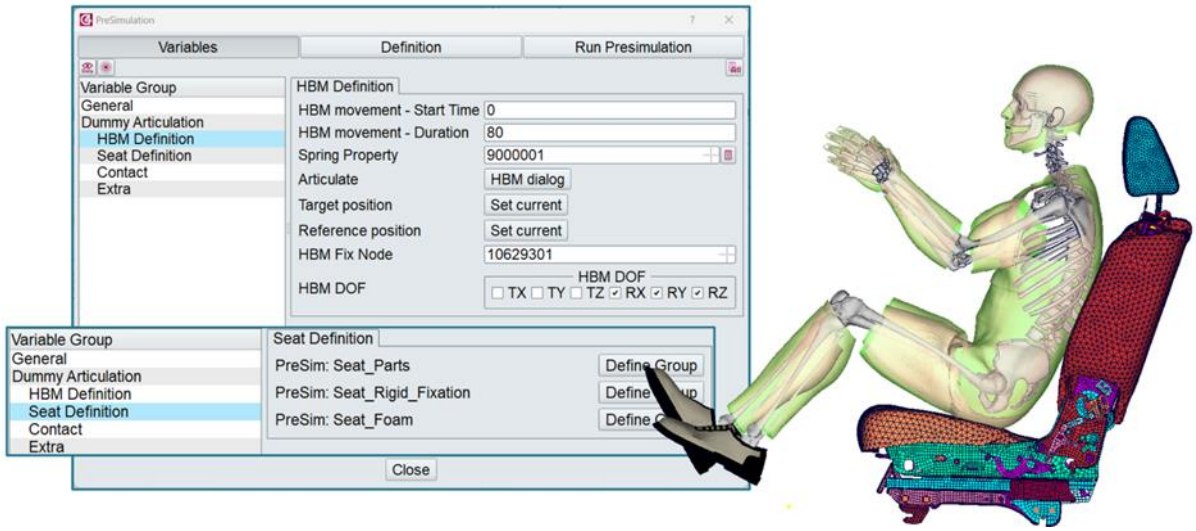

Fig.3: Example of process definition using pre-defined processes in Generator4 to position the HBM while also calculating the foam deformation.

But not only this, the great advantage of the Generator4 PreSimulation module is its great flexibility and simplicity. The module can be used in any of the following ways:

1. The user can take advantage of pre-defined processes, where only adapting a phew variables is necessary.
2. It is also possible to combine several pre-defined processes to generate a more complex one.
3. The last possibility is to define anew positioning methods and save it as a template for late usage.

The last option listed is particularly interesting in the current situation. The vast number of positions to be evaluated and the wide variety of vehicle passenger compartment layouts for autonomous vehicles will most probably imply the necessity of tailored solutions, such as the ones any user can achieve by using Generator4.

Fig.4: Automated belt creation in Generator4

3.2.3 Belt creation

Another common job when pre-processing a HBMs to be used in any test, is to generate a seatbelt and fasten the HBM with it. Generator4 has another dialog box dedicated to this. And it allows the user to create belt models with ease, including buckle and pillar redirections, for example.

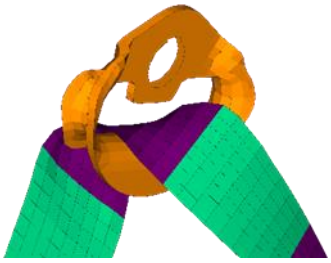

Fig.5: Detail of created belt displaying automatically created redirections at the B-Pilar

In addition, once the belt is generated the user can make fine adjustments that apply morphing techniques. Interactively, again using drag & drop, the engineer can adapt the belt webbing to the complex shapes of an HBM until the desired belt shape and fit is achieved.

4 Evaluation of human body models

4.1 Related difficulties

Checking and evaluating the damage for such a realistic model is not easy.

With human Body models, one has access to substantial amounts of information. Given the degree of detail of the models, it is possible to evaluate almost everything.

This alone represents a challenge for engineers. But not only this: For many simulation engineers, the medical terminology used in the evaluation and handling of these models is unfamiliar. The technical profile they present does not usually cover such different areas as automotive and medicine.

This fact, together with the size of the model itself, makes it necessary to use a powerful post-processor to move these calculations easily and navigate through the available data comfortably and quickly.

Fig.6: Sled simulation using Hans

4.2 Animator4 solution for HBM evaluation with ease

Animator4 is a postprocessor that stands out in the field of numerical simulation for its great capacity to work with very large models with fluidity and simplicity. That is why the handling of humanoid models is not a problem in this aspect.

The difficulty when evaluating a simulation involving a HBM lies in the handling of the different tissues of the model and their evaluation.

These models' realism means navigating them without appropriate assistance can be difficult, given the considerable number of organs and properties. Also, the evaluation of human organs requires certain medical knowledge that the average user does not usually possess.

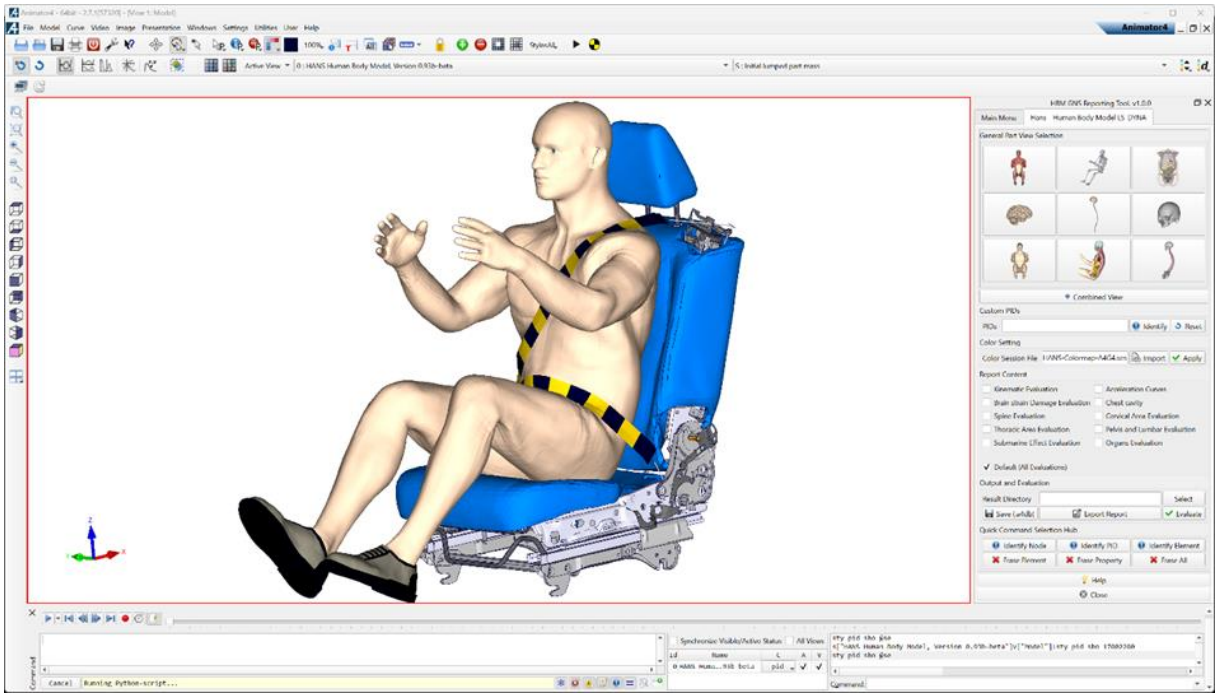

Fig.7: Animator4 layout while using the HBM report tool.

To facilitate the simulation engineer's work, a dedicated tool is being developed to help with the handling and evaluation of the HBM. Among the functionalities offered, the following stand out:

1. A dashboard with different predefined views of the HBM. With a single click, the most common and useful views are obtained.

2. A list with the organs and systems of the HBM to be able to directly control its visibility, without the need to evaluate the properties that compose it.

3. A properties evaluation area with which the user can isolate specific properties, identify or locate them in the model to make evaluations as required by the project and then automatically return to the previous view of the model.

4. Generation of an automatic report that evaluates the possible damages suffered by the HBM in its main organs automatically. An interactive document is generated, which the user can later manipulate and extend according to the project's needs. Subsequently it can be exported as A4-Database or as word or pdf document.

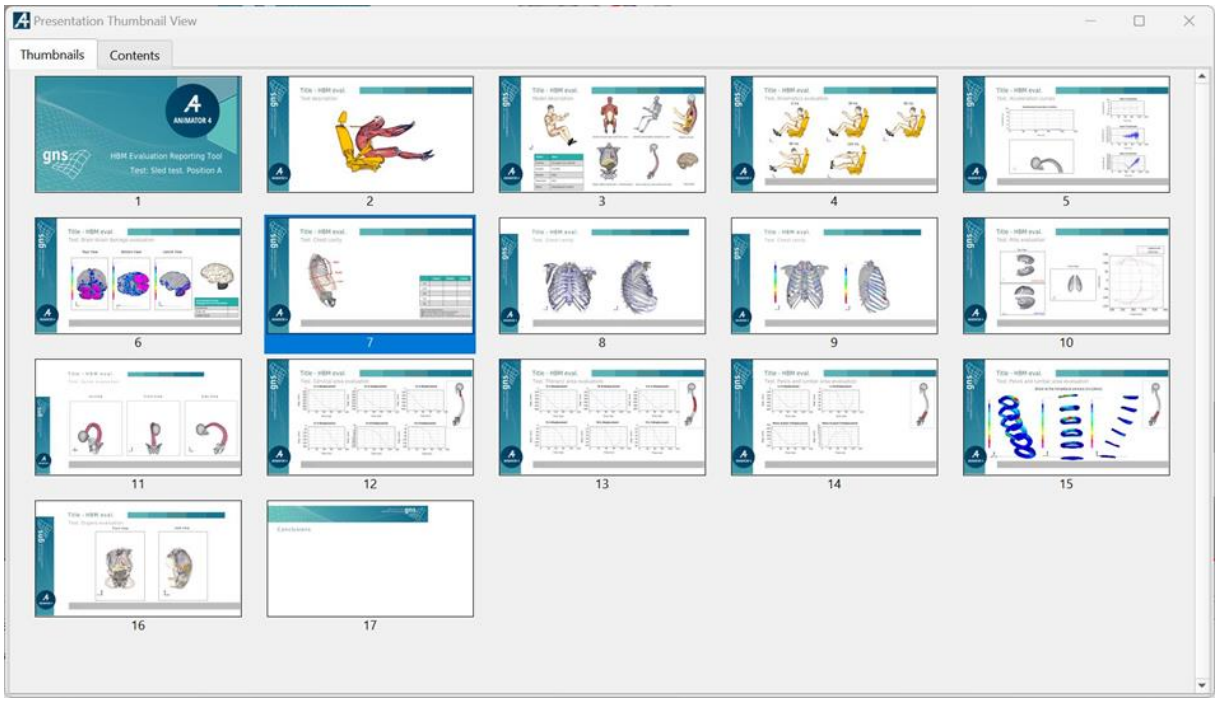

Fig.8: Example of the automated report created with Animator4.

5 Summary

During the presentation you will see a description of the processes to be followed in Generator4 and Animator4 when working with human body models.

Generator4 provides a flexible and dynamic pre-processor that helps to pose any mannequin or human body model in an effortless way. First articulating the model as a solid rigid to define the desired position and then defining a pre-simulation that provides realistic positions for the human body model.

Animator4 is as well presented as a powerful post-processing software capable of managing the most complex models. Focusing on the new tool currently in development to improve the user's experience. Adapted to human body models, it will certainly help engineers to understand the complex results that a human model can provide.

6 Literature

[1] DYNAmore website. https://www.dynamore.de